Application of Risk-Based Screening Levels and Decision Making to Sites With Impacted Soil and Groundwater

Volume 1: Summary Tier 1 Lookup Tables

Prepared by:

California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, California 94612

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Contact:
Roger D. Brewer, Ph.D.
Associate Engineering Geologist
Telephone: 1-510-622-2374
E-mail: rdb@rb2.swrcb.ca.gov

OR

Sampath Rangarajan
Water Resources Control Engineer
Telephone: 1-510-622-2381
E-mail: sr@rb2.swrcb.ca.gov

California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, California 94612

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Winston H. Hickox
Secretary for Environmental Protection

California Regional Water Quality Control Board

San Francisco Bay Regional Water Quality Control Board

Internet Address: http://www.swrcb.ca.gov
1515 Clay Street, Suite 1400, Oakland, California 94612
Phone (510) 622-2300 •• FAX (510) 622-2460

Gray Davis
Governor

TO: Interested Parties File No. 1210.40 (RDB)

FROM: Stephen A. Hill
Toxics Cleanup Division Chief
SF Bay Region RWQCB

DATE: December 26, 2001

SUBJECT: December 2001 Update to Risk-Based Screening Levels for Impacted Soil and Groundwater

Staff at the San Francisco Bay Regional Water Quality Control Board (RWQCB) have prepared an updated edition of the technical document entitled *Application of Risk-Based Screening Levels and Decision Making to Sites With Impacted Soil and Groundwater* (Interim Final - December 2001). This edition replaces the previous August 2000 version of the document. Volume 1 presents lookup tables of conservative, Tier 1 Risk-Based Screening Levels (RBSLs) for over 100 chemicals commonly found at sites impacted by releases of hazardous substances. Volume 2 describes how the RBSLs were developed and provides detailed tables and appendices in support of the summary lookup tables.

Highlights of updates to the August 2000 Version of the RBSL document include the following:

- Reprioritization of drinking water goals for chemicals lacking promulgated Primary Maximum Contaminant Levels (Volume 2, Appendix 1, Section 3.1);
- Revision of human health screening levels based on updates to California-specific toxicity factors (including MTBE);
- Additional information on risk-based evaluation of arsenic in soil (Volume 1, Section 2.9 and Figure 4);
- Addition of dibromochloropropane, 1,4 dioxane and perchlorate to RBSL tables;
- Modification of groundwater screening levels for potential indoor-air impacts at sites with fine-grained, vadose-zone soils (Volume 2, Appendix 1, Section 3.3 and Table E-1b);
- Addition of soil gas screening levels for evaluation of indoor-air impacts in buildings over impacted groundwater (Volume 2, Appendix 1, Section 3.3 and Table E-2b);
- Addition of information on the use of laboratory-based, soil leaching tests (Volume 1, Section 3.2).

A more detailed summary of updates is provided in Volume 2, Appendix 8 of the document. Changes to specific screening levels in the RBSL tables are highlighted in red in electronic versions of this document.

The document is intended to help expedite the preparation of environmental risk assessments at sites where impacted soil and groundwater has been identified. As an alternative to preparing a formal, detailed risk assessment, soil and groundwater data collected at a site can be directly compared to the RBSLs and the need for additional work evaluated. This document may especially be beneficial for use at sites with

limited impacts, where the preparation of a more formal risk assessment may not be warranted or feasible due to time and cost constraints.

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For further information, please contact:

Roger D. Brewer
California RWQCB - San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612
tel: 1-510-622-2374
e-mail: rdb@rb2.swrcb.ca.gov

Table of Contents

FIGURES

TABLES

APPENDICES (IN VOLUME 2)

Executive Summary

Risk-based screening levels (RBSLs) for soil and groundwater are presented for over 100 chemicals commonly found at sites impacted by releases of hazardous substances. The RBSLs are considered to be conservative. Under most circumstances, and within the limitations described, the presence of a chemical in soil or groundwater at concentrations below the corresponding RBSL can be assumed to not pose a significant threat to human health and the environment. Additional evaluation will generally be necessary at sites where a chemical is present at concentrations above the corresponding RBSLs. Active remediation may or may not be required, however, depending on site-specific conditions and considerations. This document may especially be beneficial for use at sites with limited impacts, where the preparation of a more formal risk assessment may not be warranted or feasible due to time and cost constraints.

The RBSLs were developed to address environmental protection goals presented in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995) of the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These goals include:

Surface Water and Groundwater:
- Protection of drinking water resources;
- Protection of aquatic biota;
- Protection against adverse nuisance conditions.

Soil:
- Protection of human health;
- Protection of groundwater;
- Protection of terrestrial biota;
- Protection against adverse nuisance conditions.

The RBSLs are presented in a series of four lookup tables. Each table reflects a specific combination of soil, groundwater and land-use characteristics that strongly influence the magnitude of environmental risk at a given site. This allows the user to select RBSLs that are most applicable to a given site.

The RBSL document presents a "tiered" approach to environmental risk assessments. Under "Tier 1", sample data are directly compared to RBSLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. In a "Tier 2" risk assessment, a selected component(s) of the Tier 1 RBSLs is modified with respect to site-specific considerations. An example may be the adjustment of a screening level for direct exposure with respect to an approved, alternative target risk level. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 RBSLs. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments. Risk assessment models and assumptions

that depart significantly depart from those used to develop the Tier 1 RBSLs are described in a more traditional, "Tier 3" risk assessment. The Tier 1 methodology can, however, still provide a common platform to initiate a Tier 3 risk assessment and help ensure that all potentially significant environmental concerns are considered.

The Tier 1 RBSLs presented in the lookup tables are NOT regulatory "cleanup standards". Use of the RBSLs and this document in general is intended to be entirely optional on the part of the regulated facility and subject to the approval of the case manager in the overseeing regulatory agency. The presence of a chemical at concentrations in excess of an RBSL does not necessarily indicate that adverse impacts to human health or the environment are occurring; this simply indicates that a potential for adverse risk may exist and that additional evaluation is warranted. RBSLs presented for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels (e.g., many petroleum-related compounds). Use of the RBSLs as cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more site-specific risk assessment.

Reliance on only the Tier 1 RBSLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health, sites where physical conditions differ drastically from those assumed in development of the RBSLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed. (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where significant concerns may exist. Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

The RBSLs should NOT be used to determine when impacts at a site should be reported to a regulatory agency. All releases of hazardous substances to the environment should be reported to the appropriate regulatory agency in accordance with governing regulations. The lookup tables will be updated on a regular basis, as needed, in order to reflect changes in the referenced sources as well as lessons gained from site investigations and field observations.

1

Introduction

1.1 Purpose

Preparation of detailed environmental risk assessments for sites impacted by releases of hazardous chemicals can be a time consuming and costly effort that requires significant expertise in a multiple of disciplines, including toxicology, geology, ecology, chemistry, physics and engineering, among others. For small-business owners and property owners with limited financial resources, preparation of such risk assessments can be time and cost-prohibitive. Alternative, low-cost, "prepackaged" risk assessments are often inadequately comprehensive, however, inconsistent between sites with similar impacts and hampered by technical errors or omissions. Such risk assessments ultimately require a significant amount of time and resources for proper review, revision and approval.

As a means to partially address this problem, this document presents a series of conservative, risk-based screening levels (RBSLs) for soil and groundwater that can be directly compared to environmental data collected at a site. Each RBSL is intended to comprehensively address the most common types of environmental concerns encountered at impacted sites. Within noted limits, risks to human health and the environment as defined for the purpose of this document can be considered to be insignificant at sites where concentrations of chemicals of concern do not exceed the respective RBSLs. The presence of chemicals at concentrations above the RBSLs does not necessarily indicate that a significant risk exists at the site. It does, however, generally indicate that additional investigation and evaluation of potential risk is warranted.

The introductory text of this document is kept intentionally brief with a focus on methodology rather than technical details. Supporting text and data that describe the derivation of each of the RBSLs presented are provided in the appendices (Volume 2).

1.2 Tiered Approach to Environmental Risk Assessments

This document presents a three-tiered approach to environmental risk assessment. The development of the RBSLs and their use in "Tier 1" environmental risk assessments is briefly described in Section 2. Under "Tier 1", sample data are directly compared to

RBSLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. Screening levels for over 100 commonly detected chemicals are given in a series of lookup tables. The tables are arranged in a format that allows the user to take into account important, site-specific factors that help define environmental concerns at a given property.

Under "Tier 2", a selected component(s) of the models used to develop the Tier 1 RBSLs is modified with respect to site-specific data or considerations. Examples include adjustment of the assumed thickness of impacted soil in the Tier 1 indoor-air impact model or use of an approved, alternative target risk level for direct-exposure concerns. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 RBSLs. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments.

Under Tier 3, the user employs alternative risk models and modeling assumptions to develop site-specific screening or "cleanup" levels or quantitatively evaluate the actual risk posed to human and/or ecological receptors by the impacted media. The Tier 1 methodology can be used, however, to provide a platform to initiate Tier 3 risk assessments and help expedite preparation and review of these assessments.

1.3 Comparison To Existing Screening Levels

Both Region IX of the U.S. Environmental Protection Agency (USEPA 2000) and the City of Oakland (Oakland 2000) have prepared lookup tables of risk-based screening levels for soil and water. The lookup tables presented in this document represent an expansion of this work to reflect the broader scope of environmental concerns put forth in the Regional Water Quality Control Board (RWQCB) Basin Plan (RWQCBSF 1995). Differences and similarities between the RBSL document and these programs are summarized below.

1.3.1 USEPA Region IX PRGs

The U.S. Environmental Protection Agency (USEPA) Region IX "Preliminary Remediation Goals" or "PRGs" are intended to address human health concerns regarding direct exposure with impacted soils (USEPA 2000). The equations used to develop the USEPA PRGs are generally consistent with human health risk assessment guidance prepared by the Department of Toxic Substances Control, including the CalTOX model (CalEPA 1994a) and the documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). As noted in Chapter 3.0, use of the CalTOX model and other CalEPA guidance documents model may be necessary where more detailed risk assessments are required.

As discussed in the USEPA Region IX document, the PRGs are primarily intended to address human direct-exposure with impacted soil and "...do not consider impact to groundwater or address ecological concerns." (USEPA 2000). Expansion of the USEPA PRGs in the lookup tables presented in this document primarily includes:

- Modification of soil PRGs to reflect CalEPA-specific toxicity factors;
- Adjustment of PRGs for noncarcinogens to reflect a target hazard quotient of 0.2 to address potential cumulative health concerns;
- Addition of direct-exposure screening levels for construction and trench workers exposure to subsurface soils;
- Addition of soil and groundwater screening levels for indoor-air impact concerns;
- Addition of groundwater screening levels for the protection of surface water quality;
- Use of a more rigorous model to develop soil screening levels for protection of groundwater quality;
- Addition of soil screening levels for urban area, ecological concerns;
- Addition of soil and groundwater "ceiling levels" to address nuisance and general resource degradation concerns; and
- Addition of soil and groundwater screening levels for Total Petroleum Hydrocarbons (TPH).

Use of the USEPA Region IX PRGs in the lookup tables is discussed further in Section 2.2 of Appendix 1.

1.3.2 City of Oakland RBSLs

A brief comparison of the RWQCB and the City of Oakland approaches to the development of risk-based screening levels is provided in Table 1-1. Since 1999, the City of Oakland has promulgated risk-based look-up tables through its Urban Land Redevelopment (ULR) Program. The ULR Program is a collaborative effort by the City of Oakland and the principal agencies charged with enforcing environmental regulations in Oakland to facilitate the cleanup and redevelopment of contaminated properties (Oakland 2000). It includes innovative institutional mechanisms for tracking residual contamination and ensuring long-term compliance with risk management plans. The ULR Program is coordinated by the City and is specific to Oakland sites.

The City of Oakland approach is based on the guidelines prescribed in *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1995). The Guidance Document, Technical Background Document and other information on the Oakland ULR program is available on the internet at www.oaklanddpw.com/urlprogram. Modifications have been made to better address child exposure and recreational water use scenarios. In addition, many input values reflect Oakland-specific geologic, hydrogeologic and climatic conditions (Oakland Technical Background 2000 and updates). These values may not be appropriate for other areas within the RWQCB's jurisdiction.

The RWQCB has agreed that the Oakland look-up tables are appropriate for use at Oakland sites under the conditions and limitations discussed in the ULR Program Guidance (memo dated August 3, 2001; RWQCBSF 2001). In particular, sites where surface or groundwater conditions present ecological, aesthetic, taste or odor concerns may require additional analysis. Active remediation to address these concerns may not be necessary at most sites in Oakland not near sensitive water bodies, however, due to its highly-developed, urban setting.

1.3.3 Prior RWQCB Guidance

The RWQCB Basin Plan ("Basin Plan") presents generic soil screening levels of 1.0 mg/kg total volatile organic compounds (VOCs) and 10 mg/kg semi-volatile organic compounds (SVOCs, RWQCBSF 1995). The Basin Plan states that the need to develop chemical-specific screening is to be evaluated on a site-by-site basis. As can be inferred from the detailed RBSLs provided in Appendix 1, the Basin Plan screening level for total VOCs is probably adequate to overly conservative for gasoline-range petroleum fuel mixtures at most sites. Chemical-specific RBSLs for benzene and MTBE are less than 1 mg/kg, due to their human toxicity and/or mobility in soil. The prevalence of less toxic and mobile VOCs in gasoline-range fuel mixtures (e.g., toulene, ethylbenzene, xylenes, etc.), however, would generally ensure that a total VOC screening level of 1 mg/kg adequately addresses concerns regarding these compounds in the absence of chemical-specific RBSLs. The total VOC screening level is in all likelihood overly conservative for heavier fuel mixtures that lack significant amounts of benzene and MTBE (e.g., diesel fuel).

For direct-exposure, human health concerns, the Basin Plan screening level of 1 mg/kg for total VOCs as presented in the Basin Plan is adequate to marginally over-conservative for the most commonly detected chlorinated solvents (e.g., tetrachloroethylene, trichloroethane, trichloroethlene, etc.). From a modeling perspective, the screening level may be somewhat under-conservative for potential leaching and groundwater protection concerns (e.g., see Appendix 1, Table G). The model used to generate screening levels for leaching of chemicals from soil conservatively assumes, however, that the impacted soil was situated within one meter of groundwater. At the vast majority of sites where this is the actual case, groundwater has already been impacted by the main mass of chemicals and direct monitoring provides a more accurate evaluation of leaching impacts. For sites where impacted soil is situated greater than 10 meters from groundwater, model-generated screening levels developed by other agencies suggest that a screening level of 1 mg/kg (or more) may be adequate for chlorinated VOCs (e.g., HIDOH 1995).

The Basin Plan screening level of 10 mg/kg for total semi-volatile organic compounds (SVOCs) is probably overly conservative for these compounds for groundwater protection purposes. For soils impacted with carcinogenic SVOCs, the Basin Plan screening level has traditionally been used in conjunction with human-health screening

levels presented in the USEPA PRGs. The PRGs are also referenced in this document although with some modifications.

The Basin Plan references a TPH soil screening level of 100 mg/kg for the protection of drinking water resources. A similar screening level was developed for use in this document. As noted in the lookup tables and discussed in Appendix 1, however, this screening level is considered to be overly conservative for heavy, residual fuels (fuel oil #6, motor oil, etc.) as well as for use at sites that do not pose a direct threat to drinking water or surface water resources.

1.4 Chemicals Not Listed In Lookup Tables

The lookup tables list 100-plus chemicals most commonly found at sites with impacted soil or groundwater. Inclusion of RBSLs for additional chemicals is a relatively straight-forward process, provided that adequate supporting data are available. To obtain RBSLs for chemicals not listed in the lookup tables, the interested party should contact the RWQCB staff noted at the beginning of this document. Development of RBSLs will be carried out in the same manner as done for the listed chemicals. As an alternative, RBSLs may be developed by qualified persons and submitted to the overseeing regulatory agency for review (refer to Section 3.0).

1.5 Limitations

The RBSLs are intended to be conservative for use at the vast majority of impacted sites in developed areas. As discussed in Chapter 3, however, use of the risk-based screening levels may not be appropriate for final assessment of all sites. Examples include:

- Sites that have a high public profile and warrant a detailed, fully documented environmental risk assessment;

- Sites with less than 1.5m (five feet) of low permeability clay and silt between impacted groundwater and the ground surface (including potential downgradient areas; applies only to use of groundwater screening levels for sites with fine-grained, vadose-zone soils);

- Sites with high rainfall and subsequent high surface water infiltration rates (i.e., infiltration >28 inches (720mm) per year),

- Sites where inorganic chemicals (e.g., metals) are potentially mobile in leachate due to soil or groundwater conditions different than those assumed in development of the lookup tables (e.g., low pH at mine sites);

- Sites where impacts pose heightened threats to sensitive ecological habitats (e.g., presence of endangered or protected species);

- Sites where the thickness of vadose-zone soils impacted by volatile organic compounds is greater than five meters (15 feet); and

- Sites where more than three known or suspected carcinogens or more than five chemicals with similar noncarcinogenic health effects have been identified.

Examples of other site characteristics that may warrant a more detailed environmental risk assessment are discussed in Chapter 3 (see also Appendix 1, Chapter 2). Under such circumstances, the Tier 1 RBSLs may still be useful in initial identification of potential problem areas and in developing strategies to cost-effectively develop a more site-specific environmental risk assessment. Additional information on the need for and development of site-specific, environmental risk assessments is presented in Chapter 3.

The Tier 1 RBSLs presented in the lookup tables are NOT required, regulatory "cleanup standards". Use of the RBSLs as actual cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more detailed environmental risk assessment. RBSLs presented for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels. For example, soil RBSLs presented for many of the petroleum-related compounds and Total Petroleum Hydrocarbon (TPH) are driven by the protection of groundwater quality and beneficial uses but do not consider the widely recognized potential for natural attenuation. If actual threats to groundwater quality can be demonstrated to be minimal through monitoring, then significantly less stringent screening levels may be applicable. Additional guidance regarding the management of impacted soil and groundwater at petroleum-release sites is provided in the following documents (refer also to overseeing regulatory agency):

- *Interim Guidance on Required Cleanup at Low-Risk Fuel Sites* (RWQCBSF 1996);

- Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates (SWRCB 2000).

Copies of these documents can be obtained from the RWQCB.

Table 1-1. Comparison of RWQCB and Oakland Risk-Based Approaches

		RWQCB	[1]Oakland
General Approach	Tiers	One tier of look-up tables. Includes separate screening levels for indoor air concerns based on soil type.	Two tiers of look-up tables: Tier 1 table applicable at any Oakland site; Tier 2 tables (3) account for site-specific soil types (Merritt Sands, sandy silts, and clayey silts) and alternate target risk. Tier 3 spreadsheets provided.
	Target Cancer Risk Level	10^{-6}	10^{-6} for Tier 1; 10^{-5} for Tier 2.
	Target Noncancer Hazard Quotient	0.2 (with option for site specific adjustment)	1.0 (with requirement to address cumulative risk as necessary)
	Ceiling Levels	"Ceiling levels" to protect against nuisance concerns, free-product mobility, and resource quality	No "ceiling levels"; recommends removal of mobile or potentially-mobile free product.
	Total Petroleum Hydrocarbons	Screening levels for TPH included	No TPH screening levels.
Soil Pathways	Definition of Surface Soils	0-3 meters below ground surface.	0-1 meter below ground surface.
	Direct Exposure, Inhalation of Volatiles	USEPA PRG model (USEPA 2000a). Assumes "infinite" source thickness for volatile organic compounds.	ASTM (1995) model. Assumes infinite source unless mass balance conditions violated based on 1.0 m thick source.
	Surface Soil Ecological Concerns	Surface soil screening levels for terrestrial biota included.	Recommends site-specific analysis when significant ecological habitats are threatened.
	Subsurface Soils	Direct-exposure soil screening levels for Construction/ Trench Worker exposure scenario.	No screening levels for this scenario; recommends a site-specific analysis as warranted.
Groundwater	Leaching Model	Employs the SESOIL model.	Employs the ASTM (1995) model.
	Leaching of Inorganic Compounds	No soil screening levels; recommends laboratory tests.	Soil screening levels for inorganic compounds, based on a neutral pH.
	Surface Water Protection	Groundwater screening levels for the ecological and aesthetic protection of surface water.	Screening levels for recreational use of groundwater and surface water. Recommends site-specific analysis of ecological and aesthetic concerns as warranted.
Indoor Air	Thickness of Soil Source	Assumes 5 meters. Recommends site-specific analysis as warranted.	Assumes "infinite" source thickness.
	Convective Flow	Incorporates convective flow in indoor-air impact model.	Does not Incorporate convective flow (i.e., assumes no pressure differential) in indoor-air impact model.
	Surface Soil Screening Levels	Includes screening levels for protection of indoor air for both surface and subsurface soils.	Recommends site-specific analysis and controls for shallow soils (<1m) and use of screening levels for deeper soils.

1. *Oakland Risk-Based Corrective Action: Technical Background Document: City of Oakland, Environmental Services Division*, January, 2000 (and updates), www.oaklanddpw.com/urlprogram.

2

Tier 1 Lookup Tables

2.1 Development of Lookup Tables

Environmental risk assessments may be carried out in either a "forward" mode, where actual risks are quantified based on concentrations of a chemical in an impacted media, or "backward" mode, where acceptable concentrations of a chemical in a given media (i.e., risk-based screening levels) are developed based on specified, target risk levels. The Risk-Based Screening Levels (RBSLs) presented in this document represents an example of the latter. Tier 1 RBSLs for soil and groundwater are summarized in Tables A through D. Each RBSL in the tables collectively addresses environmental concerns stated or inferred in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995), prepared by the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These concerns include:

Groundwater Quality:

- Protection of human health
  - Current or potential drinking water resource;
  - Emission of vapors to building interiors;
- Protection of aquatic biota (discharges to surface water);
- Protection against nuisance concerns (odors, etc.) and general resource degradation.

Soil Quality:

- Protection of human health
  - Direct/indirect exposure with impacted soil;
  - Emission of vapors to building interiors;
- Protection of groundwater quality (leaching of chemicals from soil);
- Protection of terrestrial ecological biota (inferred from groundwater goals);
- Protection against nuisance concerns (odors, etc.) and general resource degradation (inferred from groundwater goals).

This scope of environmental concerns is depicted schematically in Figure 1. The degree to which each concern influences environmental risk at a given site depends both on the nature of potential exposure and the toxicity and mobility of the chemical. This is generally described in a "conceptual site model" developed for the site.

Site characteristics that play an important role in estimating potential environmental risk or developing site-specific cleanup levels include:

- Physical location of the impacted soil (e.g., currently or potentially exposed at the ground surface versus isolated in the subsurface);
- Beneficial use of the groundwater immediately underlying the site or otherwise potentially threatened by the release (e.g., drinking water resource threatened versus no drinking water resource threatened);
- Current and anticipated future use of the site (e.g., residential land use permitted or commercial/industrial land use only).

In order to include consideration of these site characteristics in the final RBSLs, four different tables were prepared (Tables A through D). Each table reflects varying combinations of site characteristics:

- Table A – Surface soils, potential drinking water resource threatened;
- Table B – Surface soils, potential drinking water resource not threatened;
- Table C – Subsurface soils, potential drinking water resource threatened;
- Table D – Subsurface soils, potential drinking water resource not threatened;

Each of the tables subsequently provides separate soil screening levels for residential (i.e., unrestricted) and commercial/industrial land-use scenarios.

For each chemical listed in the lookup tables, screening levels were selected to address each applicable environmental concern under the specified combination of site characteristics. The lowest of the individual screening levels for each concern was selected for inclusion in the summary Tier RBSL tables presented in Volume 1 of this document. This ensures that the final RBSL included in the summary lookup tables is adequately protective of each of the environmental concerns addressed. Use of the summary Tier 1 tables in Volume 1 of this document allow a quick evaluation of site data to determine if potential environmental concerns exists, although the exact nature of these concerns cannot be determined without reference to the detailed tables provided in Appendix 1

An example of the selection of summary, Tier 1 RBSLs is presented Figure 2 (tetrachlorethylene (PCE); screening levels for surface soils, drinking water resource threatened, residential land use desired). A more detailed discussion of this example is

provided in Appendix 1, as are individual screening levels for all chemicals listed in the Tier 1 tables.

2.2 Use of Lookup Tables

The step-by-step use of the lookup tables is summarized below and discussed in more detail in the following sections. A summary of the process is also provided in Figure 3. Additional discussion of the format of a Tier 1 environmental risk assessment that should accompany use of the lookup tables is provided in Section 2.11.

Step 1 - RBSL Updates and Applicability

Check with the overseeing regulatory agency to determine if the RBSLs can be applied to the subject site. If so, ensure that the most up-to-date version of this document is being used.

Step 2: Identify All Chemicals of Potential Concern

An environmental risk assessment must be based on the results of a thorough site investigation, where all chemicals of potential concern have been identified. A summary of the site investigation results should be included in the risk assessment in order for it to be reviewed as a "stand alone" document." A general outline of site investigation information that should be included in a Tier 1 risk assessment is provided in Section 2.11.

Step 3: Selection of Lookup Table(s)

Evaluate the potential for groundwater that is a current or potential source of drinking water to be impacted by the release. In most cases, it must be initially assumed that drinking water resources could potentially be impacted (see Section 2.3). Next, determine the depth below ground surface to the top of impacted soil (see Section 2.4). This site information is then used to select the most appropriate lookup table (see Figure 3).

Steps 4: Determine Desired Land Use (soil RBSLs only)

In the selected lookup table, select RBSLs for soil from one of the two land-use columns in the table, depending on the present and desired future use of the site ("Residential Land Use Permitted" or "Commercial/Industrial Land Use Only"). Screening levels for residential land used can generally be assumed to be adequate for unrestricted use of the property. **(For evaluation of commercial/industrial properties, it is highly recommended that site data be compared to RBSLs for both residential and commercial/industrial land use.** Reference only to RBSLs for commercial/industrial land use will in most cases require that a covenant to the deed be prepared that restricts use of the property to these purposes only (see Section 2.9)).

Steps 5 and 6: Select Soil and/or Groundwater RBSLs

Based on the desired land use(s), select appropriate soil RBSLs. RBSLs for groundwater are provided in the last two columns of each table and are not dependent on land use or depth to impacted soil. Groundwater RBSLs for "Elevated Threat to Surface Water" will generally only need to be considered only at sites with large plumes adjacent to a surface water body (see Section 2.7). Replace RBSLs with naturally occurring, background concentrations of chemicals of concern (e.g., arsenic) or laboratory method reporting levels if higher (see Section 2.8).

Step 7: Determine Extent of Impacted Soil and/or Groundwater

Using the selected RBSLs, determine the extent of impacted soil or groundwater and areas of potential environmental concern at the site and offsite, as required. For sites where sample data are limited, it will be most appropriate to compare the maximum-detected concentrations of chemicals of concern to the RBSLs. For sites where an adequate number of data points are available, the use of statistical methods to estimate more site-specific exposure point concentrations and evaluate environmental risks may be appropriate. The exposure point concentration is generally selected as the lesser of the maximum-detected concentration and the 95% upper confidence interval of the arithmetic mean of sample data. Guidance for the estimation of exposure point concentrations, use of "non-detect" data, and other issues is provided in the CalEPA documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a), among other sources. As discussed in these documents, sample data collected outside of impacted areas should generally not be included in estimation of exposure point concentrations. **For residential land use scenarios, sample data should be averaged over no more than a 1,000 ft^2 area.**

Steps 8 and 9: Evaluate The Need For Additional Investigation or Corrective Actions; Submit Appropriate Reports

Based on a comparison of available site data to the RBSLs, evaluate the need for additional action at the site (e.g. additional site investigation, remedial action, preparation of a more site-specific risk assessment, etc.). This is then summarized in the Tier 1 Environmental Risk Assessment report and workplans for additional corrective actions as needed (see Section 2.11). Decisions for or against additional actions should always be made in conjunction with guidance from the overseeing regulatory agency.

2.3 Groundwater Beneficial Use

As stated in the San Francisco Bay Region *Water Quality Control Plan* ("Basin Plan", RWQCB 1995), "Unless otherwise designated by the Regional Board, all groundwaters are considered suitable, or potentially suitable, for municipal or domestic water supply." All groundwater beneath a given site should be initially treated as a potential source of drinking water unless otherwise approved by the RWQCB office. For the purposes of this document, it is also assumed that all shallow groundwater will ultimately discharge

to a body of surface water and potentially impact aquatic organisms (see Section 2.7). Soil and groundwater RBSLs were therefore developed to be protective of both drinking water resources and aquatic habitats. This is discussed in greater detail in Chapters 2 and 3 of Appendix 1.

The Basin Plan recognizes, however, that site-specific factors may render naturally occurring groundwater unsuitable for potential drinking water purposes. Tables B and D in this document are intended for use at such sites. The RBSLs presented in these tables consider the potential discharge of groundwater to surface water but do not consider potential impacts to sources of drinking water. Use of these tables for screening level environmental risk assessments must be approved by the RWQCB but may not necessarily require regulatory "de-designation" of groundwater beneficial use.

Hydrogeologic criteria presented in the Basin Plan for potential exclusion of a given occurrence of groundwater from consideration as a potential source of drinking water include:

- Total dissolved solids in groundwater is greater than or equal to 3,000 mg/L; OR

- Water bearing unit is not sufficiently permeable to produce an average, sustained yield of 200 gallons of water per day.

Groundwater in coastal areas, geothermal fields, etc., may contain levels of dissolved solids that make the water unsuitable as a potential source of drinking water. In addition, the permeability of soils and sediments that lack a significant amount of coarse-grained material (or fractures, in the case of bedrock) may be too low to allow for an adequate, sustained yield of groundwater. Unconsolidated geologic units that are comprised of less than 20% sand-size (or larger) material or more than 30% clay-size material are typically not considered to be viable "aquifers" or potential sources of useable groundwater (inferred from Fetter 1994). The potential for a given unit of bedrock to serve as a viable source of groundwater similarly depends on the primary and secondary porosity in the rock and the quality of the groundwater. Consideration must also be made for the potential migration of groundwater out of a geologic unit that in itself is insufficiently permeable to be considered to be an aquifer and into a more permeable unit that could serve as a viable source of drinking water.

In general, soil and groundwater screening levels are more stringent for sites that threaten both a potential source of drinking water and a body of surface water (e.g., compare Tables A and B). This is particularly true for chemicals that are highly mobile in the subsurface and easily leached from impacted soil. For certain chemicals that are especially toxic to aquatic life (e.g., several long-chain hydrocarbons, pesticides and heavy metals), however, screening levels for sites that threaten drinking water resources

may be driven by surface water/aquatic life protection concerns. This is discussed in more detail in Appendix 1.

2.4 Surface Versus Subsurface Soils

For the purposes of this document, a depth of three meters (approximately 10 feet) was conservatively used to delineate between shallow, "surface" soils where there is a potential for regular direct exposure by residents and/or office workers and deeper, "subsurface" soils where only periodic exposure during construction and utility maintenance work is considered likely. In general, and particularly in urbanized areas, human receptors and terrestrial flora and fauna are not likely to be directly exposed on a regular basis to impacted soils located more than one to two meters below the ground surface. Future exposure and unmanaged reuse of impacted soils that had been "capped" with clean soil and left in place is, however, a significant issue in deciding appropriate cleanup actions for a site. A depth of three meters is consistent with guidance presented in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). This is regarded as the maximum, likely depth that impacted soil could at some point in the future be excavated and left exposed at the surface during typical redevelopment activities. The potential for deeper soils to be brought to the surface during large-scale redevelopment activities should be evaluated on a site-by-site basis.

The full suite of environmental concerns noted in Figure 1 was considered in development of RBSLs for surface soils. For subsurface soils, potential regular exposure by residents or commercial/industrial workers and impacts to terrestrial flora and fauna were not considered. As a result, RBSLs for relatively non-mobile chemicals are generally less stringent than correlative RBSLs for surface soils (e.g., compare PCB RBSLs in Tables A and C). For chemicals that are easily leached from soil or potentially emitted to the air as a volatile gas, however, groundwater and indoor air protection concerns usually drive selection of the final RBSL regardless of the depth of the impacted soil. This is the case for several of the highly volatile, chlorinated organic compounds. As a result, correlative surface and subsurface soil RBSLs are identical (e.g., compare trichloroethylene RBSLs in Tables A and C).

If impacted soil extends across the three-meter dividing line between shallow "surface soil" and deep "subsurface soil", it may be appropriate to use a separate set of screening levels for each zone (e.g., Table A for the surface soils and Table C for the subsurface soils). As discussed in Section 2.9, however, the pros and cons of remediating subsurface soils to surface soil criteria should be evaluated on a site-by-site basis. This may help avoid concerns regarding future disturbance and reuse of deeper soils.

As another alternative, the less stringent RBSLs for subsurface soils could be applied to shallower soils under a Tier 2 or Tier 3 risk assessment (refer to Chapter 3), provided that

appropriate actions to prevent future exposure and unmanaged reuse are taken. Such controls may include (but not necessarily be limited to):

- placement and maintenance of adequate cap or other risk-management mesaures to eliminate potential direct exposure;
- modeling and/or direct field measurement to evaluate potential impacts to indoor air due to vapor emissions; and
- preparation of a risk management plan and other appropriate institutional controls (e.g., deed restrictions) in order to prevent unauthorized disturbance of the soil in the future and allow for appropriate management of the soil if it is exposed.

The need to consider these actions at sites with impacted soils situated more than three meters below the ground surface should be discussed with the overseeing regulatory agency on a site-by-site basis.

2.5 Land Use

Land uses are categorized based on the assumed length, duration and magnitude of potential human exposure. The category "Residential Land Use Permitted" is intended for use at sites where future land-use restrictions are not desirable or allowed. RBSLs listed under this category incorporate conservative assumptions regarding long-term, frequent exposure of children and adults to impacted soils in a residential setting (see Appendices 1, Section 2.2 and Appendix 2). In contrast, the land-use category "Commercial/Industrial Use Only" assumes that only working age adults will be present at the site on a regular basis. Direct-exposure assumptions incorporated into the soil RBSLs are somewhat less conservative than assumptions used in the residential land-use scenario.

Land use should be selected with respect to the current and foreseeable future use of the site in question. Reference to adopted General Plan zoning maps and local redevelopment plans is an integral part of this process. Use of the lookup tables for sites with other land uses (e.g., agriculture, parkland, etc.) should be discussed with and approved by the overseeing regulatory agency. As the category heading implies, use of the soil RBSLs listed under "Commercial/Industrial Use Only" places implicit land-use restrictions on the affected property. While this may be considered acceptable for properties currently zoned for such purposes, the need for such restrictions in the future should be seriously weighed against the cost-benefit of remediating the property to meet the sometimes more conservative but less restrictive RBSLs for "Residential Land Use Permitted". **As a general rule, data for commercial/industrial sites should always be compared to both residential and commercial/industrial RBSLs. Implications for land-use restriction are discussed in more detail in Section 2.9.**

2.6 Coarse-Grained Versus Fine-Grained Soils

The model used to evaluate the emission of volatile compounds from soil and groundwater to indoor air is highly sensitive to the permeability of soil present in the vadose zone (refer to Appendix 3). As a result, Tier 1 screening levels for indoor-air concerns can be significantly more stringent (i.e., lower) for sites underlain by permeable, coarse-grained soils (e.g., unconsolidated sands and gravels or highly fractured bedrock) versus those underlain by less permeable, fine-grained soils (e.g., unconsolidated clays and silts). In order to account for this potential site condition in the lookup tables, separate screening levels were generated for model scenarios involving coarse-grained soils versus fine-grained soils.

This is reflected in the lookup tables by the presence of two numbers in a column for some chemicals. For example, refer to the residential soil RBSL for bromodichloromethane in Lookup Table A (0.025 (0.48) mg/kg). The first number in provided is the RBSL for sites with very permeable, coarse-grained soils in the vadose zone soils. The second number (in parentheses) is the RBSL for sites characterized by fine-grained soils of relatively low permeability in the vadose zone. In this example, the soil RBSL for sites with coarse-grained soils (0.025 mg/kg) is more than an order of magnitude more stringent than the RBSL for sites with fine-grained soils (0.48 mg/kg). For other volatile chemicals, the difference can be less dramatic but still worth evaluating. If only one RBSL appears in the lookup table for a volatile chemical then either potential indoor-air impacts were not considered (inadequate chemical data for modeling purposes), the chemical is so volatile that soil type did not matter (e.g., vinyl chloride), or risks for that chemical were driven by another environmental concern (e.g., benzene). This can be determined by reviewing the supporting lookup tables in Appendix 1.

For the purposes of this document, coarse-grained soils are conservatively defined as soils in which 20% or more of the material composing the soil is sand-size or greater. "Sand-size" is defined as material that is equal to or greater than 0.075 mm in diameter (i.e., will not pass through a U.S. Standard 200 mesh sieve). Conversely, fine-grained soils are defined as soils where greater than 80% of the material composing the soil is less than 0.075 mm diameter (i.e., will pass through a U.S. Standard 200 mesh sieve, <20% sand-size). These definitions are consistent with default parameter values for soil types used in the indoor air impact models (refer to Appendix 1) and are consistent with commonly used soil classifications.

2.7 Threat To Surface Water Habitats

For the purposes of the Tier 1 lookup tables, it is assumed that impacted or potentially impacted groundwater at all sites could at some time migrate offsite and discharge into a

body of surface water. This could occur due to natural groundwater migration processes or to human activities such as dewatering of construction sites.

Groundwater RBSLs listed under the lookup table categories of "Drinking Water Resource Threatened" (Tables A and C) and "Drinking Water Resource NOT Threatened" (Tables B and D) include consideration of chronic (or alternative) surface water quality criteria. Surface water quality criteria are selected as the groundwater RBSL when lower than other criteria considered, including drinking water standards. This is the case for several pesticides and heavy metals listed in the tables. Benthic flora and fauna communities situated below or at the groundwater/surface water interface are assumed to be exposed to the full concentration of chemicals in impacted groundwater. Use of a generic "dilution factor" to adjust the surface water protection screening levels with respect to dilution of groundwater upon discharge to surface water was therefore not considered. Consideration of dilution/attenuation factor and alternative groundwater screening levels for the protection of surface water quality may, however, be appropriate on a site-specific basis.

An additional series of groundwater RBSLs are presented in the lookup tables under the category of "Elevated Threat To Surface Water Habitats". These surface water standards are intended to address potential bioaccumulation of chemicals in aquatic organisms and subsequent human consumption of these organisms. The discharge of impacted groundwater to a body of surface water should not lead to impacts that exceed these standards. Consideration of the standards during groundwater investigations and cleanup actions will be most appropriate at sites where large plumes of impacted groundwater threaten to cause long-term impacts to bodies of surface water and minimal dilution of discharging groundwater is anticipated. the standards will generally need to be considered at sites with small, isolated plumes of impacted groundwater located some distance from a body of surface water. Although these plumes could conceivably migrate offsite and discharge into a body of surface water in the distant future, impacts are likely to be short-lived and the plumes are likely to become significantly diluted as they mix with surface water. The need for a more detailed study of potential groundwater impacts on surface water with respect to bioaccumulation of chemicals in aquatic organisms should be evaluated on a site-by-site basis. This may include the need for more stringent soil cleanup levels (to prevent additional leaching) and development of a more comprehensive, ecological risk assessment

The soil and groundwater screening levels presented in the lookup tables do not directly address the protection of sediment quality. Site-specific concerns could include the accumulation and magnification of concentrations of highly sorptive chemicals in sediment over time due to long-term discharges of impacted groundwater. This may be especially true for sites with petroleum-impacted groundwater. Potential erosion and runoff of surface soils from impacted sites may also need to be considered, particularly at sites impacted with metals and pesticides that are situated near a sensitive body of surface water. The need for a more detailed, ecological risk assessment of impacts to sediment

should be evaluated on a site-by-site basis and discussed with the overseeing regulatory agency.

2.8 Substitution of Laboratory Reporting Limits and Ambient Background Concentrations for RBSLs

In cases where an RBSL for a specific chemical is less than the laboratory method reporting limit for that chemical (as agreed upon by the overseeing regulatory agency), it is generally acceptable to consider the method reporting limit in place of the screening level. A potential example is the soil RBSL for dioxin.

In cases where the naturally occurring, background concentration of a chemical exceeds the RBSL given in the lookup table, it is generally acceptable to use the background concentration as the screening level. This may be a common issue for heavy metals in soil, particularly for arsenic and total chromium. Arsenic is often reported to be present at background concentrations well above the residential surface soil RBSL of 0.39 mg/kg and the commercial/industrial RBSL of 2.7 mg/kg. Figure 4 suggests steps that could be taken when evaluating a site for potential arsenic impacts. At progressively higher concentrations above natural background, additional steps may be necessary to ensure adequate protection of human health and the environment.

Background levels of chromium may also be problematic with respect to the Tier 1 RBSLs presented for "total" chromium. Soil RBSLs presented for total chromium are based on an assumed 1:6 ratio of highly toxic chromium VI to relatively non-toxic chromium III (USEPA 2000). Chromium VI is considered to be especially toxic if inhaled. The Tier 1 RBSL for total chromium under all land-use scenarios (13 mg/kg, see also Appendix 1, Table K series) is in turn driven by potential risk to utility and construction workers, who are assumed to inhale significant amounts of dust in comparison to residents or office workers. The total chromium RBSL is likely to be below typical background levels of chromium III in soils, however, and in itself not useful for identifying potential environmental concerns at a site. If collected, total chromium data will probably be most useful for initial identification of areas with apparent elevated levels of chromium. Once identified, samples from these areas should be specifically analyzed for chromium VI and chromium III and the results compared to the respective RBSLs presented in the Tier 1 tables.

The natural background concentration of a chemical in soil or groundwater can vary significantly between and even within sites and is most appropriately evaluated by the collection of on-site samples or by reference to local data collected from past studies. Guidance for estimating background concentrations of chemicals in soil and groundwater is provided in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). Sources of background metal concentration in soils in California

include the University of California-Riverside report *Background Concentrations of Trace and Major Elements in California Soils* (UCR 1996). Although the Upper Confidence Limits presented are incorrect, the Lawrence Berkeley Laboratory document *Protocol for Determining Background Concentrations if Metals in Soil at Lawrence Berkeley National Laboratory* (LBNL 1995) also provides useful raw data for background concentrations of metals in soils in the Bay Area.

2.9 Implied Land-Use Restrictions Under Tier 1

Allowing the option to tie screening levels or cleanup levels to site-specific land use and exposure conditions can save considerably in investigation and remediation costs. For example, the screening level for polychlorinated biphenyls (PCBs) in surface soils is 0.22 mg/kg in residential areas but 1.0 mg/kg for commercial/industrial areas (see Table A). For more isolated subsurface soils, the RBSL for PCBs is 5.6 mg/kg (Tables C and D), driven by potential, periodic exposure of utility and construction workers (Appendix 1). Even higher levels of PCBs could potentially be allowed to remain in place onsite provided that adequate controls to mitigate potential exposure are put into effect (e.g., permanent cap, protection of groundwater, etc.).

The application of final cleanup levels less stringent than those appropriate for potential residential (i.e., unrestricted) exposure will, however, place restrictions on future use of the property. For example, if a site is remediated using RBSLs (or alternative criteria) intended for commercial/industrial land use, only then the site cannot be used for residential purposes in the future without additional evaluation (e.g., remediation of soil to meet residential use of property and/or reevaluation of residual impacts under a more conservative, residential risk assessment). In most cases, this will require the imposition of a covenant to the deed that restricts future use of the property.

The use of RBSLs for subsurface soils at a site similarly assumes that the impacted soil remain isolated below the ground surface "for eternity". For residential areas, future disturbance of soil situated greater than three meters is generally considered to be unlikely (CalEPA 1996a) and use of the subsurface soil RBSLs below this depth without restrictions may be reasonable (see Section 2.4). During the redevelopment of commercial/industrial properties, however, excavation and removal of soils from depths in excess of five or even ten meters could take place (e.g., for underground parking garages). The need to impose enforceable, institutional controls for proper management of impacted, deep soils at properties where the subsurface RBSLs (or alternative cleanup levels) are applied should be discussed with the overseeing regulatory agency on a site-by-site basis.

Land-use restrictions inherent in the selection of RBSLs from the Tier 1 lookup tables (or assumptions used in site-specific risk assessments) should be kept as minimal as possible. **Concentrations of chemicals in impacted soils left in place at a**

commercial/industrial site should always be compared to both commercial/industrial AND residential RBSLs (or alternative criteria for unrestricted land use). If the soils in fact meet residential land-use RBSLs after cleanup, this should be clearly stated in the site closure report. Recognizing this point may prove important should the site unexpectedly become desirable for other use in the future (e.g., residential, school day care, health care, etc.). **Assumptions that impacted soil at a property will remain isolated at shallow depths under pavement, buildings or some other type of "cap" should likewise be avoided if at all possible.** Such assumptions can place serious and oftentimes unnecessary restrictions on the future use and redevelopment of a site. If done, appropriate covenants to the property deed should be prepared and methods to prevent or manage future disturbance of the soil should be clearly described and ensured. A foresighted approach in the use of Tier 1 RBSLs and alternative, site-specific cleanup levels will allow more flexibility in future use of a site, help avoid unexpected complications during site redevelopment and minimize the liability of future land owners.

2.10 Cumulative Risks at Sites With Multiple Chemicals of Concern

Risk posed by the presence of multiple chemicals with similar health affects at a site is considered to be additive or "cumulative." For example, the total risk of cancer posed by the presence of two carcinogenic chemicals in soil is the sum of the risk posed by each individual chemical. The same is true for chemicals that cause noncarcingenic health effects. A summary of example target health effects for the chemicals listed in the lookup tables is provided in Appendix 1 (Table L).

Use of RBSLs for single chemicals is therefore limited to the extent that the screening levels remain protective of human health should other chemicals with similar health effects also be present. Soil RBSLs are considered to be adequate for use at sites where no more three carcinogenic chemicals or five chemicals with similar noncarcinogenic ("systemic") health effects are present. This is based on a combination of conservative exposure assumptions and target risk factors in direct-exposure models. Refer to Appendix 1, Section 1.4, for additional discussion of this subject.

2.11 Framework For a Tier 1 Environmental Risk Assessment

Tier 1 environmental risk assessments should serve as "stand alone" documents that provide a good summary of environment impacts at a site and assess the threats posed to human health and the environmental by these impacts. The risk assessment can be prepared as a component of a site investigation or remedial action report or as a separate document. In formation on each of the topics listed below should be addressed in report that presents the risk assessment, however (after MADEP 1995). Together, this information is intended to provide a basic "conceptual model" of site conditions. The

level of detailed required for each topic will vary depending on site-specific considerations.

1. Summarize Past, Current and Anticipated Future Site Activities and Uses:
   - Describe past and current site uses and activities;
   - Describe foreseeable future site uses and activities. **(Always include a comparison of site data to residential RBSLs to evaluate need for formal land-use restrictions; see Section 2.9).**
2. Summary of Site Investigation:
   - Identify all types of impacted media;
   - Identify all sources of chemical releases;
   - Identify all chemicals of concern;
   - Identify magnitude and extent of impacts that exceed RBSLs to extent feasible and applicable (include maps of site with isoconcentration contours for soil and groundwater);
   - Identify nearby groundwater extraction wells, bodies of surface water and other potentially sensitive ecological habitats;
   - Ensure data are representative of site conditions.
3. Summarize Appropriateness of Use of Tier 1 Lookup Tables and RBSLs (see Section 1.5):
   - Do Tier 1 RBSLs exist for all chemicals of concern?
   - Does the site have a high public profile and warrant a fully documented, detailed environmental risk assessment?
   - Does soil and groundwater conditions at the site differ significantly from those assumed in development of the lookup tables (e.g., low pH at mine sites)?
   - Do impacts pose a heightened threats to sensitive ecological habitats (e.g., presence of endangered or protected species)?
   - Is the thickness of vadose-zone soils impacted by volatile organic compounds greater than five meters (15 feet, see Section 1.5 and Appendix 1);
   - Have more than three carcinogens or five chemicals with similar noncarcinogenic health effects been identified (see Section 2.10)?
   - Other issues as applicable to the site.
4. Soil and Groundwater Categorization (see Sections 2.3, 2.4 and 2.6):
   - State the regulatory beneficial use of impacted or potentially impacted groundwater beneath the site; discuss the actual, likely beneficial use of groundwater based on measured or assumed quality of the groundwater and the hydrogeologic nature of the soil or bedrock containing the groundwater.
   - Characterize the soil type(s) and location of impacted soil as applicable to the lookup tables (e.g., soil stratigraphy, soil texture and permeability, depth to and thickness of impacted soil, etc.).

5. Exposure Point Concentrations (see Section 2.2, Step 7):

- Identify maximum concentrations of chemicals present in impacted media;
- Describe how alternative exposure point concentrations were determined (e.g., 95% UCLs), if proposed, and provide supporting data.
- Discuss the need to evaluate groundwater data with respect to surface water standards for potential bioaccumulation of chemicals in aquatic organisms ("Elevated threat to surface water body"), due to the size of the plume, the proximity of the plume to a body of surface water and the potential for minimal dilution of groundwater upon discharge to surface water (see Section 2.7).
- Discuss how background concentrations of chemicals were determined, if considered for use in the risk assessment (see Section 2.8).

6. Selection of Tier 1 RBSLs and Comparison to Site Data (see Section 2.2)

- Summarize how Tier 1 RBSLs were selected for use at the site with respect to the information provided above and additional assumptions as applicable.
- Compare site data to the selected summary Tier 1 RBSLs (presented in Volume 1) and discuss general results.
- If desired or recommended, compare site data to detailed RBSLs for individual environmental concerns (presented in Volume 2, Appendix 1) and discuss specific, potential environmental concerns present at site.

7. Conclusions (see Section 2.9):

- Describe the extent of soil and groundwater impacts above Tier 1 RBSLs, using maps and cross sections as necessary.
- Discuss if a condition of potential risk to human health and the environment exists at the site.
- Discuss if a more site-specific risk assessment is warranted at the site.
- Present a summary of recommended future actions proposed to address environmental concerns ay the site.
- Discuss the need to impose land-use restrictions and institutional controls at the site based on the results of the Tier 1 assessment (e.g., requirements for caps, etc.; need for covenant to deed to restrict land use to commercial/industrial purposes only, etc).

The above list is not intended to be exhaustive or representative of an exact outline required for all Tier 1 risk assessments. Requirements for completion of an adequate site investigation and Tier 1 Risk Assessment should be discussed with the overseeing regulatory agency.

3

Tier 2 and 3 Environmental Risk Assessments

3.1 Conditions Warranting More Detailed Risk Assessments

Use of the Tier 1 risk-based screening levels is optional and independent environmental risk assessments may be undertaken for any site. In some cases, site conditions may negate the full use of the Tier 1 RBSLs and require preparation of a Tier 2 or Tier 3 risk assessment. Examples of site conditions that may warrant a more site-specific or detailed risk assessment include (see also Section 1.5):

- Site where alternative target risk levels or chemical-specific toxicity factors may be acceptable to the regulatory agency (see Appendix 1, Section 2.2);
- Sites where the thickness of vadose-zone soils impacted by volatile organic compounds greater than five meters (soil screening levels for potential indoor air concerns may not be adequately conservative; see Appendix 1, Section 2.3);
- Sites where summary Tier 1 RBSLs for soil are driven by potential leaching concerns and groundwater data are available for evaluating actual groundwater impacts (main mass of impacted soil should be in contact with groundwater; see Appendix 1, Section 2.4);
- Sites where inorganic chemicals (e.g., metals) cannot be assumed to be immobile in soil (potential threat to groundwater quality; see Appendix 1, Section 2.4);
- Sites where the depth to groundwater is greater than ten meters below the base of impacted soil (soil screening levels for leaching concerns may be excessively conservative; see Appendix 1, Section 2.4);
- Sites where protected terrestrial habitats or other ecologically sensitive areas are threatened (soil RBSLs may not be adequately conservative; see Appendix 1, Section 2.5);
- Sites where engineered controls will be implemented to eliminate or reduce specific exposure pathways (avoid whenever possible; see Section 2.9); and

- Sites where field observations or site conditions otherwise indicate that the RBSLs may not be adequately conservative or may be excessively conservative.

Reliance on only the Tier 1 RBSLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health; sites where physical conditions differ drastically from those assumed in development of the RBSLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed. (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where these concerns may be present (see Section 3.3.5). Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

Evaluation of landfills and sites impacted by mine wastes may in particular require the preparation of a detailed, site-specific assessment of potential groundwater and surface water impact concerns due to the possible elevated mobility of metals and other chemicals. Soil leaching models incorporated into the Tier 1 RBSLs assume typical, ambient physio-chemical conditions in soil and groundwater (e.g., soil pH 5.0 to 9.0) and the relatively immobility of heavy metals and organic chemicals with very high sorption factors (e.g., PCBs, PAHs, stc.). This assumption may not hold true at many landfill and mine sites, where extreme pH and Eh conditions could lead to substantial mobility of these compounds. In these and other related cases, more rigorous field and laboratory studies may be required to adequately assess risk to human health and the environment.

Site-specific risk assessments are grouped under the loosely defined terms "Tier 2" and "Tier 3". The nature of these risk assessments is briefly discussed below.

3.2 Tier 2 Environmental Risk Assessments

3.2.1 Purpose

Tier 2 environmental risk assessments are intended to be relatively easy and cost-effective to prepare. Preparation of Tier 2 risk assessments will require a thorough understanding of the manner in which the Tier 1 RBSLs were developed, however. Under Tier 2, specific Tier 1 screening levels are adjusted or deleted to more closely reflect site conditions or alternative risk assumptions. Replacing only targeted components of the Tier 1 RBSLs reduces the need to prepare and justify an independent, detailed risk assessment when Tier 1 RBSLs cannot or should not be fully applied and

greatly reduces the time and cost incurred by both the regulated business and the overseeing regulatory agency in finalizing the risk assessment.

For example, the Tier 1 screening level for leaching concerns may not need to be considered at sites where groundwater monitoring data indicate that leaching impacts from soil to groundwater are minimal or not posing an adverse risk. In another example, the site-specific thickness or depth of impacted soil may be input into the model used to develop soil screening levels for indoor air impact concerns and a more appropriate screening level easily recalculated. A common modification under Tier 2 may also include the adjustment of target risk level for carcinogens in soils at commercial/industrial sites from 10^{-6} to 10^{-5}, following completion of a through site investigation (and likely preparation of a covenant to the deed that formally restricts land use). This will effectively increase the direct-exposure screening levels for carcinogens by a factor of ten. In these examples, all other components of the Tier 1 RBSL are retained for use in the risk assessment. The modifications to Tier 1 assumptions are described and justified in the text of the report and the revised set of screening levels are presented.

3.2.2 Example Tier 2 Modifications of Tier 1 RBSLs

A more detailed list of potential Tier 2 modifications to Tier 1 screening levels is presented below (refer also to Appendix 1). These examples are not intended to reflect the full range of modifications possible:

Groundwater Screening Levels

Drinking Water:

- Exclusion of drinking water impact concerns based on natural groundwater quality or geologic characteristics of groundwater containing unit (e.g., brackish groundwater in coastal areas);

Indoor Air Impacts:

- Use of site-specific data for model input parameters (depth to groundwater, soil properties, building characteristics, target risk or hazard index, etc.);
- Use of soil gas and/or indoor air data to more directly evaluate potential impacts;
- Use of alternative chemical toxicity factors or target risk levels;

Surface Water Impacts:

- Exclusive use of freshwater or saltwater screening levels;
- Consideration of alternative surface water screening levels;
- Consideration of groundwater monitoring data and observed plume migration over time;
- Consideration of site-specific dilution effects during potential discharge of groundwater to surface water (generally not recommended except in highly developed and disturbed water front properties);

Ceiling Levels:

- Use of alternative ceiling levels and/or site-specific observations and considerations regarding nuisance concerns;

General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the RBSL.

Soil Screening Levels

Direct Exposure:

- Use of alternative chemical toxicity factors or target risk levels;
- Elimination of direct-exposure concerns through imposition of institutional controls;
- Exclusion of direct-exposure concerns due to depth of impacted soil below ground surface (e.g., >10 meters bgs);

Indoor Air Impacts:

- Use of site-specific data for model input parameters (thickness and depth of impacted soil, soil properties, building characteristics, target risk or hazard index, etc.);
- Use of soil gas and/or indoor air data to more directly evaluate potential impacts;
- Use of alternative chemical toxicity factors or target risk levels;

Groundwater Protection (leaching effects):

- Consideration of alternative, target groundwater levels;
- Use of groundwater monitoring data to evaluate leaching impacts and groundwater quality concerns (most appropriate where main mass of chemical is in contact with groundwater);
- Use of laboratory leaching test to evaluate potential groundwater impacts (see Section 3.3.3);

Ecological Impact Concerns:

- Use of alternative screening levels based on site studies or published data;
- Reconsideration of need to include eco-based screening levels in highly industrialized areas;

Ceiling Levels:

- Use of alternative ceiling levels and/or site-specific observations and considerations regarding nuisance concerns;

General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the RBSL.

In each of these examples, an alternative screening level is generated for the specified environmental concern and re-compared to site data. Models and assumptions used to generate each of the Tier 1 screening levels are discussed in detail in Appendix 1. The format of the Tier 2 Risk Assessment Report should be similar to that outlined for Tier 1 reports. Adjustments to Tier 1 screening levels should be clearly described and justified within the report and additional information included as necessary.

3.3 Tier 3 Environmental Risk Assessments

3.3.1 Purpose

Under Tier 3, alternative models and assumptions are used and fully justified to develop a detailed, comprehensive risk assessment. Portions of the Tier 1 models may still be retained for some components of the risk assessment. A detailed review of the preparation of Tier 3 environmental risk assessments is beyond the scope of this document. A few potentially useful methods and some general cautions are highlighted

below. Common references for the preparation of Tier 3 risk assessments are provided at the end of this section.

3.3.2 Mass-Balanced Soil Volatilization Factor Model

A good example of a useful, alternative model for evaluating soil direct-exposure concerns is the mass balanced volatilization factor model provided in the USEPA document *Soil Screening Guidance* (USEPA 1996) and used in the City of Oakland RBCA program (Oakland 2000). This model was used in earlier versions of the USEPA Preliminary Remedial Goals (PRGs) document (pre-1995). The current PRG model, and the model thus reflected in the direct-exposure screening levels presented in this document, assumes an infinite thickness of contaminated soil at a site. For highly volatile chemicals such as vinyl chloride and even benzene, this is excessively conservative and could require the presence of tens of meters impacted soil over a large area to be justifiable. The mass-balanced model allows for the input of the actual thickness of impacted soil at a site and can result in substantially less stringent, and more realistic, screening or cleanup levels for direct-exposure concerns. Note, however, that groundwater protection concerns (i.e., soil leaching) or potential indoor-air impacts often drive screening level environmental concerns at sites impacted with highly mobile, volatile chemicals. This concerns and others, as appropriate, should be evaluated in conjunction with direct-exposure concerns.

Easy-to-use spreadsheets that incorporate the mass-balanced direct-exposure model are available for downloading from the Hawaii Department of Health website (HIDOH 1995, DETIER2 spreadsheet developed by editor of this document) as well as the City of Oakland website (Oakland 2000), among other sources. Care should be taken to ensure that default toxicity factors presented in these and other spreadsheets are consistent with those used in California (see Appendix 1, Table J). In the future, a similar spreadsheet may be directly available from the RWQCB (refer to contacts listed at front of document).

3.3.3 Laboratory-Based Soil Leaching Tests

Laboratory-base soil leaching tests offer an alternative to the use of conservative, model-derived soil screening levels for groundwater protection concerns (refer to Section 2.4 in Appendix 1). These tests may especially useful for evaluating soils impacted by inorganic chemicals (e.g., metals and salts) and relatively nonsorptive and nonvolatile organic chemicals. The USEPA Synthetic Precipitation Leaching Procedure (SPLP) is one example (USEPA 1994). The SPLP test differs from the more commonly referenced Toxicity Characteristic Leaching Procedure (TCLP) for hazardous waste in that it is specifically designed to evaluate the mobility of organic and inorganic compounds in soils. The results of an SPLP test are compared to regulatory levels for disposal of materials in landfills and this is then used to determine the type of landfill most

appropriate for disposal of the soil (e.g., lining, leachate collection system requirements, etc.).

The SPLP test was **not** specifically developed to evaluate leaching of chemicals from soil outside of a controlled, landfill environment but can be used to do so with some caveats. From a groundwater protection standpoint, one goal is to predict the dissolved-phase concentration of a chemical in the pore space of a saturated soil sample (i.e. the leachate) through either models or laboratory tests. The SPLP test does **not** directly provide this information. Under the SPLP test method, 100 grams of soil are added to two liters of reagent water. This leads to significant dilution of potential "leachate" derived from a simple saturation of the sample. For example, the pore volume of a 100-gram sample of soil with 35% effective porosity is approximately 20 cm^3. Adding two liters, or 2,000 cm^3, of water to the sample therefore introduces a laboratory-based, leachate "dilution factor" of approximately 100 to the SPLP test results (volume extract/volume pore space). Concentrations of chemicals reported under the SPLP test might therefore be up to 100 times greater than the dissolved-phase concentration of the chemical in the leachate of a saturated sample of the soil.

The inherent dilution effect of the SPLP test method is only significant for chemicals that are highly mobile and not significantly volatile (or biodegradable). From a fate and transport perspective, the dilution factor inherent in the SPLP test could be considered to reflect the reduction in chemical concentrations through resorption, volatilization and dilution as the leachate migrates downward and mixes with groundwater. Based on comparisons of soil leaching models that take these fate and transport considerations into account (e.g., SESOIL, see Appendix 1) and those that don't (e.g., USEPA 1996), the dilution factor inherent in the SPLP test method appears to be adequately conservative for chemicals that are at least moderately sorptive (i.e., sorption coefficient of at least 100 ml/g) or highly volatile (i.e., Henry's Constant of at least 0.001 atm-m3/mole.). **For moderately sorptive and/or volatile chemicals, the results of the SPLP test can be directly compared to target groundwater goals.** This includes most of the organic chemicals listed in the RBSL lookup tables (refer to Table J in Appendix 1).

Chemicals listed in the RBSL document that are not assumed to be adequately sorptive or volatile to justify unmodified use of the SPLP test method include all inorganic compounds (including metals and perchlorate) as well as acetone, 2,4 dinotrophenol and methyl ethyl ketone (very low sorption coefficients). Chemicals that fail this test but only moderately include bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, chloraniline, 1,2 dibromoethane, 2,4 dimethylphenol, 2,4 dinitrotoluene, MTBE, phenol, 1,1,1,2-tetrachloroethane and 1,1,2,2-tetrachloroethane. **For these and other relatively nonsorptive and nonvolatile chemicals not listed in the RBSL tables, the results of the SPLP test should be divided by a factor of 100 (or a sample-specific factor) to negate the method-related dilution effect.** The sample results could then be adjusted a more chemical-specific and site-specific Dilution/Attenuation Factor (DAF). Relatively simple DAFs that only address mixing of leachate with groundwater can be calculated

using equations provided in the USEPA *Soil Screening Guidance* (USEPA 1996), among other sources. For the Bay area, simple leachate/groundwater mixing DAFs for shallow aquifers would typically fall in the range of 5 for silty soils to 20 for sandy soils (e.g., assuming 2m thick shallow aquifer, 30% effective porosity, infiltration rate of 8.0 cm/year, and hydraulic conductivities of 2m/day and 15m/day, respectively). DAFs could be much higher for areas with fast moving groundwater and/or little infiltration of precipitation and lower in areas with slow moving groundwater and/or greater infiltration of precipitation. Potentially less conservative DAFs that also address resorption, volatilization and other factors can be calculated using more rigorous models such as SESOIL (see Appendix 1).

3.3.4 Tier 3 Risk Assessments for Parklands

It is becoming increasingly common for former industrial areas to be converted into open recreational parks or even "wildlife refuges." For initial cleanup efforts, it is strongly recommended that such areas be remediated to meet unrestricted land use standards (i.e., assumed residential exposure, target Excess Cancer Risk of one-in-a-million; target Hazard Index of 1.0). Consideration of a less conservative, recreational-use only exposure scenario may indicate that substantially higher concentrations of contaminants could be left in place at the site and not pose a threat to human health. Proposed cleanup levels under this scenario are oftentimes higher (less stringent) than those that would be normally be allowed for commercial/industrial properties. This intuitively goes against the concept of developing a park as "refuge" for humans and wildlife, however. This also puts a restriction on the number of days and years that an individual is allowed to visit the park without exceeding potential health hazards. Long-term, future use of the properties for residential or other purposes is likewise difficult to ensure.

In some cases, remediation of properties that are to be converted into open land to unrestricted land-use standards may not technically or economically feasible. This should be evaluated on a site-specific basis and receive approval from the overseeing regulatory agency. In such cases, the appropriateness of allowing unrestricted access to the area should be carefully evaluated. This could include the need to formally place access restrictions on the property (i.e., based on the exposure frequency assumptions used to develop the final cleanup standards) and a need to post signs at the property entrance to warn of potential health hazards (see Section 2.9).

3.3.5 Tier 3 Reference Documents

Potentially useful reference documents for preparation of Tier 3 environmental risk assessments include the following:

Human Health Risk Assessment:

- *Superfund Exposure Assessment Manual* (USEPA 1988)
- *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual* (Part A) (USEPA 1989a);
- *Soil Screening Guidance: Technical Background Document* (USEPA 1996);
- *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites* (CalEPA 1994a);
- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b);
- *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a);
- *Exposure Factors Handbook* (USEPA 1997a);
- Sta*ndard Provisional Guide for Risk-Based Corrective Action* (ASTM 1995); and
- Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces (Johnson et. al, 1998).

Ecological Risk Assessment:

- *Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual* (USEPA 1989b);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997b), and
- *Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a,b).

Sources of additional risk assessment guidance should be sought as needed.

4

References

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SWRCB, 2000, *Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates* (DRAFT): State Water Resources Control Board, Division of Clean Water Programs, March 30, 2000.

UCR, 1996, *Background Concentrations of Trace and Major Elements in California Soils*: University of California (Riverside), Division of Agriculture and Natural Resources, March 1996.

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FIGURES

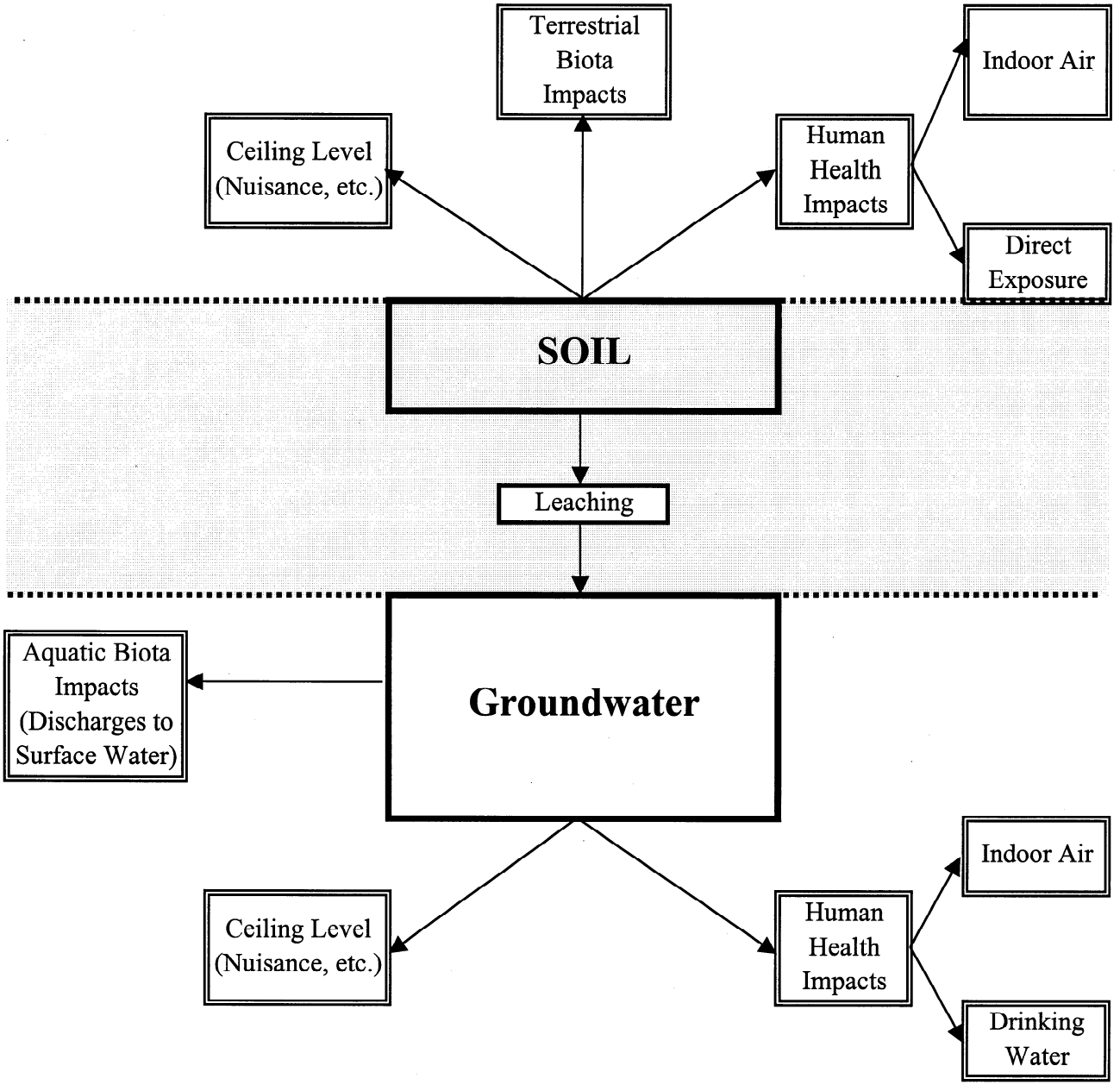

Figure 1. Summary of human health and environmental concerns considered in lookup tables. Additional site-specific conditions considered in lookup tables include groundwater utility, depth to impacted soil, soil type, land use, and threat to ecologically sensitive aquatic habitats.

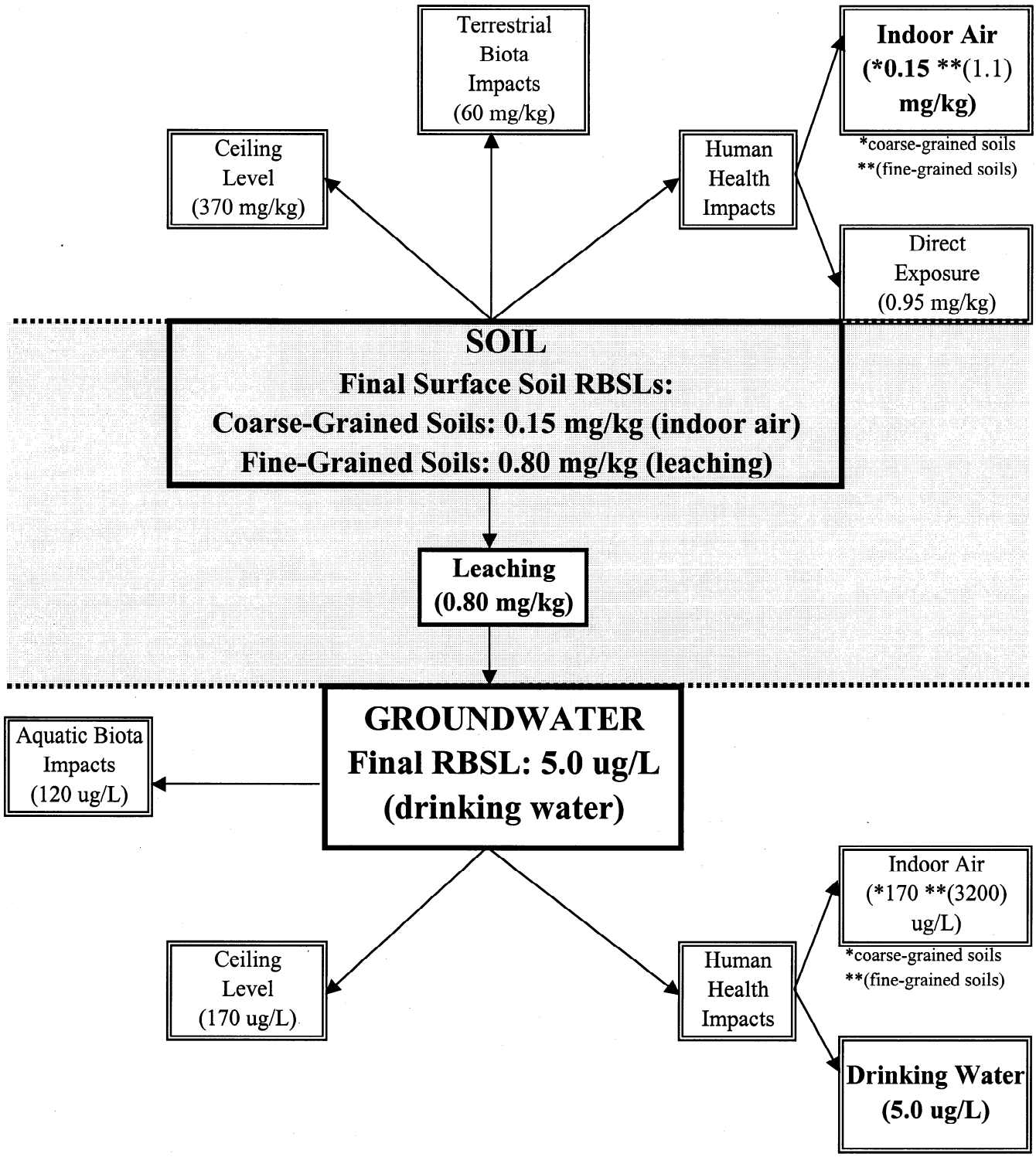

Figure 2. Summary of individual screening levels used to select final, Tier 1 soil and groundwater RBSLs for tetrachloroethylene (Table A, refer also to Tables A-1 and F-1 in Appendix 1). Based on surface soils, residential land use and potential impact to drinking water resource. Final Tier 1 RBSLs are the lowest of the individual screening levels. For sites with coarse-grained, vadose-zone soils, potential impact to indoor air drives selection of the final RBSL (0.15 mg/kg). For sites with fine-grained soils, leaching to groundwater drives selection of the final RBSL (0.80 mg/kg). Final soil RBSL reported in lookup Table A as "0.15 (0.80)". For groundwater, drinking water concerns drive selection of final RBSL (5.0 ug/L).

STEP 1: Check with the overseeing regulatory agency to ensure that the version of the lookup tables you have is up-to-date and that the screening levels can be applied to your site (see Section 1.5).

STEP 2: Select chemicals of potential concern for site based on knowledge of past site use and/or analytical data for soil or groundwater samples collected at the site.

STEP 3: Choose appropriate lookup table based on location of impacted soil and beneficial use of impacted or potentially impacted groundwater at the subject site, as summarized below:

[1]BENEFICIAL USE OF THREATENED GROUNDWATER	[2]LOCATION OF IMPACTED SOIL	
	Surface Soil (≤ 3m bgs)	[3]Subsurface Soil (> 3m bgs)
Current or Potential Source of Drinking Water	TABLE A	TABLE C
NOT a Current or Potential Source of Drinking Water	TABLE B	TABLE D

bgs: below ground surface

1. Shallow-most saturated zone beneath the subject site and deeper zones as appropriate.
2. Depth to top of impacted soil from ground surface (3 meters = 10 feet).
3. Application of Subsurface RBSLs to soils <3m deep may require institutional controls (see text).

STEP 4: Go to selected lookup table. Determine desired or anticipated future use of property - "Residential Land Use Permitted" (recommended for initial use at all sites to avoid potential land-use restrictions) vs "Commercial/Industrial Land Use Only".

STEP 5: Select soil RBSLs for chemicals of concern from appropriate land-use column in table and/or select correlative groundwater RBSLs.

STEP 6: Replace RBSLs with approved laboratory method detection limit if detection limit is greater than the RBSL. Replace RBSLs with natural background concentration of chemical if background is higher (see text and notes at end of tables).

STEP 7: Determine vertical and lateral extent of soil and/or groundwater impacted above screening levels to extent required by overseeing agency AND/OR use selected RBSLs as guide for re-use of excavated, impacted soil.

STEP 8: Evaluate additional corrective actions needed at site based on results of Step 7. (e.g., cleanup to Tier 1 RBSLs, track and monitor defined groundwater plume, develop alternative screening levels in a site-specific, Tier 2 or Tier 3 environmental risk assessment, etc.). Determine specific environmental concerns for site as needed using screening levels presented in Appendix 1.

STEP 9: Submit Tier 1 Environmental Risk Assessment and work plans for additional corrective actions, as necessary, to overseeing regulatory agency.

Figure 3. Steps to selection and use of Risk-Based Screening Levels in Tier 1 Lookup Tables (see Section 2.2).

Figure 4. Evaluation of arsenic concentrations in soil.

[1]Concentration of Arsenic in Surface Soil	[2]Basis	Residential Land Use	Commercial/Industrial Land Use	[3]Ecological Concerns
≤8 mg/kg	[4]Average background concentration for Bay Area colluvium and fill.	No action required.	No action required.	No action required.
>8 mg/kg	Potentially above background for Bay Area soils. Background could range up to 20+ mg/kg in some areas.	Further evaluation of site background concentrations required (sample data, data from nearby areas, etc.). Residential land use probably not permitted without remediation to background levels. Evaluate potential impacts to groundwater as necessary.	Further evaluation of site background concentrations required (sample data, data from nearby areas, etc.). Risk management measures needed may be needed to address potential dust impacts to nearby residential areas. Evaluate potential impacts to groundwater as necessary.	Further evaluation of potential site background concentrations required (sample data, data for nearby areas, etc.). Ecological risk assessment may be needed for areas where sensitive habitats are threatened, including potential discharge of impacted groundwater to a surface water habitat.
≥27 mg/kg	Commercial/ Industrial direct-contact screening level adjusted to target risk of 10^{-5} (see Table K-2)	Same as above.	Soil remediation and/or risk management measures needed. May include need to provide subsurface utility corridors for future redevelopment. Evaluate potential impacts to groundwater as necessary.	Same as above.
≥40 mg/kg	Ecological screening level for Commercial/ Industrial sites (see Table A-2)	Same as above.	Same as above.	Ecological risk assessment needed for sites where sensitive habitats are threatened.

For general reference only. More stringent criteria may be applied on a site-specific basis.

1. Surface soils defined as soils within 3m (10ft) of ground surface.
2. Refer to noted text or table in RWQCB *Application of Risk-Based Screening Levels* document (December 2000).
3. An ecological risk assessment may be required at lower soil concentrations than indicated for sites within or adjacent to sensitive habitats (e.g., adjacent to sensitive wetlands, endangered species threatened, etc.).
4. Based on Lawrence Berkeley Laboratory data (LBNL 1995). Corrected 95% UCL for arsenic in soils associated with colluvium and fill is 8 mg/kg (incorrectly calculated and presented as 14 mg/kg in LBL report). Highest reported concentration of arsenic in colluvium and fill is 21 mg/kg. Corrected 95% UCL for other soils ranges up to 15 mg/kg (based on data for Great Valley formation soils).

TABLES

TABLE A: SURFACE SOIL (≤3M BGS) - GROUNDWATER IS A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential RBSLs and evaluate need for formal land-use restrictions (see Section 2.9).
- Use of groundwater RBSLs for sites with fine-grained soils (in parentheses) requires presence of continuous, low permeability clay/silt unit between impacted groundwater and the ground surface ≥1.5 meters thick (see Section 1.5).

TABLE A. SURFACE SOIL (≤ 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
ACENAPHTHENE	16	16	20	-
ACENAPHTHYLENE	120	120	280	-
ACETONE	0.24	0.24	700	-
ALDRIN	0.029	0.15	0.002	0.00014
ANTHRACENE	2.9	2.9	0.73	-
ANTIMONY	6.3	40	6.0	-
ARSENIC	0.39	2.7	36	-
BARIUM	750	1500	3.9	-
BENZENE	0.045	0.045	1.0	-
BENZO(a)ANTHRACENE	0.38	1.8	0.029	-
BENZO(b)FLUORANTHENE	0.38	1.8	0.029	-
BENZO(k)FLUORANTHENE	0.38	1.8	0.029	0.049
BENZO(g,h,i)PERYLENE	5.3	5.3	0.02	-
BENZO(a)PYRENE	0.038	0.18	0.014	-
BERYLLIUM	4.0	8.0	4.0	-
BIPHENYL, 1,1-	0.65	0.65	0.50	-
BIS(2-CHLOROETHYL)ETHER	0.0002	0.0002	0.014	-
BIS(2-CHLOROISOPROPYL)ETHER	0.005	0.005	0.50	-
BIS(2-ETHYLHEXYL)PHTHALATE	160	200	12	-
BORON	1.6	2.0	1.6	-
BROMODICHLOROMETHANE	0.025 (0.48)	0.098 (1.1)	100	-
BROMOFORM	2.2	2.2	100	-
BROMOMETHANE	0.38 (0.39)	0.39	9.8	-
CADMIUM	1.7	12	1.1	-
CARBON TETRACHLORIDE	0.021 (0.059)	0.074 (0.11)	0.50	-
CHLORDANE	0.44	2.9	0.004	0.00059
CHLOROANILINE, p-	0.11	0.11	10	-
CHLOROBENZENE	3.0	3.0	50	-
CHLOROETHANE	0.85	0.85	12	-
CHLOROFORM	0.079	0.26	28	-
CHLOROMETHANE	0.42	0.42	2.7	-
CHLOROPHENOL, 2-	0.012	0.012	0.18	-
CHROMIUM (Total - assumes 1/6 ratio Cr6/Cr3)	13	13	50	-
CHROMIUM III	750	750	180	-
CHROMIUM VI	1.8	1.8	11	-
CHRYSENE	3.8	18	0.29	0.049
COBALT	40	80	3.0	-
COPPER	225	225	3.1	-
CYANIDE (Free)	100	500	1.0	-
DIBENZO(a,h)ANTHTRACENE	0.11	0.51	0.0085	0.049
DIBROMOCHLOROMETHANE	0.98	2.3	100	46

TABLE A. SURFACE SOIL (≤ 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
1,2-DIBROMO-3-CHLOROPROPANE	0.001	0.001	0.20	-
DIBROMOETHANE, 1,2-	0.0003	0.0003	0.05	-
DICHLOROBENZENE, 1,2-	0.75	0.75	10	-
DICHLOROBENZENE, 1,3-	0.47	0.47	6.3	-
DICHLOROBENZENE, 1,4-	0.13 (0.59)	0.49 (0.59)	5.0	-
DICHLOROBENZIDINE, 3,3-	0.008	0.008	0.029	0.077
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4	17	0.06	0.00084
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7	4.0	0.10	0.00059
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7	4.0	0.001	0.00059
DICHLOROETHANE, 1,1-	0.22	0.22	5.0	-
DICHLOROETHANE, 1,2-	0.006	0.006	0.50	-
DICHLOROETHYLENE, 1,1-	0.018 (0.028)	0.062 (0.12)	6.0	3.2
DICHLOROETHYLENE, Cis 1,2-	0.19	0.19	6.0	-
DICHLOROETHYLENE, Trans 1,2-	0.65	0.65	10	-
DICHLOROPHENOL, 2,4-	0.30	0.30	0.30	-
DICHLOROPROPANE, 1,2-	0.049 (0.13)	0.13	5.0	-
DICHLOROPROPENE, 1,3-	0.055 (0.057)	0.057	0.50	-
DIELDRIN	0.002	0.002	0.0019	0.00014
DIETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHENOL, 2,4-	0.68	0.68	100	-
DINITROPHENOL, 2,4-	0.040	0.040	14	-
DINITROTOLUENE, 2,4-	0.0008	0.0008	0.11	-
1,4 DIOXANE	0.0018	0.0018	3.0	-
DIOXIN (2,3,7,8-TCDD)	0.0000045	0.000032	<0.00001	0.000000014
ENDOSULFAN	0.005	0.005	0.0087	-
ENDRIN	0.0006	0.0006	0.0023	-
ETHYLBENZENE	2.5	2.5	30	-
FLUORANTHENE	40	40	8.1	-
FLUORENE	5.1	5.1	3.9	-
HEPTACHLOR	0.013	0.013	0.0036	0.00021
HEPTACHLOR EPOXIDE	0.014	0.014	0.0036	0.00011
HEXACHLOROBENZENE	0.27	1.4	1.0	0.00077
HEXACHLOROBUTADIENE	2.2	2.2	0.45	-
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	0.049	0.049	0.08	0.063
HEXACHLOROETHANE	3.0	3.0	0.90	8.9
INDENO(1,2,3-cd)PYRENE	0.38	1.8	0.029	0.049
LEAD	200	750	3.2	-
MERCURY	4.7	10	0.012	-
METHOXYCHLOR	19	19	0.03	-
METHYLENE CHLORIDE	0.076	0.076	5.0	-

TABLE A. SURFACE SOIL (≤ 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
METHYL ETHYL KETONE	3.8	3.8	4200	-
METHYL ISOBUTYL KETONE	2.7	2.7	120	-
METHYL MERCURY	1.2	10	0.003	-
METHYLNAPHTHALENE (total 1- & 2-)	0.25	0.25	2.1	-
METHYL TERT BUTYL ETHER	0.028	0.028	5.0	
MOLYBDENUM	40	40	35	-
NAPHTHALENE	1.7 (4.3)	4.3	21	-
NICKEL	150	150	8.2	-
PENTACHLOROPHENOL	4.4	5.0	1.0	-
PERCHLORATE	0.036	0.036	18	-
PHENANTHRENE	11	11	4.6	-
PHENOL	0.076	0.076	5.0	-
POLYCHLORINATED BIPHENYLS (PCBs)	0.22	1.0	0.014	0.00017
PYRENE	55	55	0.40	-
SELENIUM	10	10	5.0	-
SILVER	20	40	0.12	-
STYRENE	1.7	1.7	10	-
TETRACHLOROETHANE, 1,1,1,2-	0.020	0.020	1.3	-
TETRACHLOROETHANE, 1,1,2,2-	0.015	0.015	1.0	-
TETRACHLOROETHYLENE	0.15 (0.80)	0.53 (0.80)	5.0	-
THALLIUM	1.0	27	2.0	-
TOLUENE	2.6	2.6	40	-
TPH (gasolines)	100	100	100	
TPH (middle distillates)	100	100	100	-
TPH (residual fuels)	500	1000	100	-
TRICHLOROBENZENE, 1,2,4-	15	15	50	-
TRICHLOROETHANE, 1,1,1-	8.0	8.0	62	-
TRICHLOROETHANE, 1,1,2-	0.055 (0.091)	0.091	5.0	-
TRICHLOROETHYLENE	0.40	0.40	5.0	-
TRICHLOROPHENOL, 2,4,5-	0.18	0.18	11	-
TRICHLOROPHENOL, 2,4,6-	0.17	0.17	0.50	-
VANADIUM	110	200	19	-
VINYL CHLORIDE	0.011	0.04	0.50	-
XYLENES	1.0	1.0	13	-
ZINC	600	600	23	-

TABLE A. SURFACE SOIL (≤ 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	no criteria	no criteria
Sodium Adsorption Ratio	5.0	12	no criteria	no criteria

Notes:

Source of soil RBSLs: Refer to Tables A-1 and A-2 in Appendix 1.

Source of groundwater RBSLs: Refer to Table F-1 Appendix 1.

Category "Residential Land Use Permitted" based on residential land-use scenario and generally considered adequate for unrestricted land use.

Surface soil less than or equal to 3 meters (approximately 10 feet) below ground surface.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 1.2).

Soil RBSLs intended to address direct-exposure, indoor-air impact, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. Refer to appendices for summary of RBSL components.

Groundwater RBSLs intended to be protective of drinking water resources, surface water quality, indoor-air impacts and nuisance concerns.

Value in parentheses applicable if vadose zone soils are predominantly fine-grained, silty, clayey loams (<20% sand-size (0.075mm) or larger material; i.e. ≥80% of soil material will pass through 200 mesh sieve).

Category "Elevated Threat To Surface Water" screening levels address potential long-term impacts to surface water bodies and bioaccumulation concerns in aquatic organisms potentially consumed by humans. Not addressed in soil RBSLs.

TPH -Total Petroleum Hydrocarbons. See Appendix 1, Chapter 4 for discussion of different TPH categories.

TABLE B: SURFACE SOIL (≤3M BGS) - GROUNDWATER IS NOT A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential RBSLs and evaluate need for formal land-use restrictions (see Section 2.9).
- Use of groundwater RBSLs for sites with fine-grained soils (in parentheses) requires presence of continuous, low permeability clay/silt unit between impacted groundwater and the ground surface ≥1.5 meters thick (see Section 1.5).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.3).

TABLE B. SURFACE SOIL (≤ 3m bgs) SOIL AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
ACENAPHTHENE	16	16	23	-
ACENAPHTHYLENE	120	120	280	-
ACETONE	0.51	0.51	1500	-
ALDRIN	0.029	0.15	0.13	0.00014
ANTHRACENE	2.9	2.9	0.73	-
ANTIMONY	6.3	40	30	-
ARSENIC	0.39	2.7	36	-
BARIUM	750	1500	3.9	-
BENZENE	0.18	0.39	46	-
BENZO(a)ANTHRACENE	0.38	1.8	0.027	0.049
BENZO(b)FLUORANTHENE	0.38	1.8	7.0	0.049
BENZO(k)FLUORANTHENE	0.38	1.8	0.40	0.049
BENZO(g,h,i)PERYLENE	5.3	5.3	0.02	-
BENZO(a)PYRENE	0.038	0.18	0.014	-
BERYLLIUM	4.0	8.0	5.1	-
BIPHENYL, 1,1-	6.5	6.5	5.0	-
BIS(2-CHLOROETHYL)ETHER	0.015 (0.095)	0.061 (0.28)	122	1.4
BIS(2-CHLOROISOPROPYL)ETHER	1.3	1.3	122	-
BIS(2-ETHYLHEXYL)PHTHALATE	160	530	32	5.9
BORON	1.6	2.0	1.6	-
BROMODICHLOROMETHANE	0.025 (0.48)	0.098 (1.1)	420 (6400)	-
BROMOFORM	62	110	5100	360
BROMOMETHANE	0.38 (0.78)	1.1 (2.6)	320	-
CADMIUM	1.7	12	1.1	-
CARBON TETRACHLORIDE	0.021 (0.059)	0.074 (0.19)	9.8	4.4
CHLORDANE	0.44	2.9	0.004	0.00059
CHLOROANILINE, p-	0.11	0.11	10	-
CHLOROBENZENE	3.0	3.0	50	-
CHLOROETHANE	0.85	0.85	12	-
CHLOROFORM	0.079	0.26	28	470
CHLOROMETHANE	0.49	0.87 (1.7)	5.6 (130)	-
CHLOROPHENOL, 2-	0.12	0.12	1.8	400
CHROMIUM (Total - assumes 1/6 ratio Cr6/Cr3)	13	13	180	-
CHROMIUM III	750	750	180	-
CHROMIUM VI	1.8	1.8	11	-
CHRYSENE	3.8	4.7	0.07	0.049
COBALT	40	80	3.0	-
COPPER	225	225	3.1	-
CYANIDE (Free)	100	500	1.0	-
DIBENZO(a,h)ANTHTRACENE	0.11	0.51	0.25	0.049
DIBROMOCHLOROMETHANE	0.98	2.3	6400	-

TABLE B. SURFACE SOIL (≤ 3m bgs) SOIL AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
1,2-DIBROMO-3-CHLOROPROPANE	0.001	0.001	0.20	-
DIBROMOETHANE, 1,2-	0.014(0.10)	0.052 (0.39)	84 (280)	-
DICHLOROBENZENE, 1,2-	1.0	1.0	14	-
DICHLOROBENZENE, 1,3-	2.6	5.3	71	-
DICHLOROBENZENE, 1,4-	0.13 (1.8)	0.49 (1.8)	15	-
DICHLOROBENZIDINE, 3,3-	0.40	2.1	50	0.077
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4	17	0.06	0.00084
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7	4.0	1.4	0.00059
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7	4.0	0.001	0.00059
DICHLOROETHANE, 1,1-	0.55 (2.1)	1.9 (2.1)	47	-
DICHLOROETHANE, 1,2-	0.040 (0.46)	0.14 (1.0)	500 (910)	99
DICHLOROETHYLENE, 1,1-	0.018 (0.028)	0.062 (0.12)	9.6 (25)	3.2
DICHLOROETHYLENE, Cis 1,2-	2.7 (8.6)	7.7 (18)	590	-
DICHLOROETHYLENE, Trans 1,2-	5.3 (13)	15 (38)	590	-
DICHLOROPHENOL, 2,4-	3.0	3.0	3.0	-
DICHLOROPROPANE, 1,2-	0.049 (0.50)	0.17 (1.4)	100	39
DICHLOROPROPENE, 1,3-	0.055 (0.090)	0.19 (0.38)	65 (244)	-
DIELDRIN	0.002	0.002	0.0019	0.00014
DIETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHENOL, 2,4-	0.74	0.74	110	-
DINITROPHENOL, 2,4-	0.42	0.42	150	-
DINITROTOLUENE, 2,4-	1.6	1.7	230	9.1
1,4 DIOXANE	0.20	0.20	335	-
DIOXIN (2,3,7,8-TCDD)	0.0000045	0.000032	<0.00001	0.000000014
ENDOSULFAN	0.005	0.005	0.0087	-
ENDRIN	0.0006	0.0006	0.0023	-
ETHYLBENZENE	24	24	290	-
FLUORANTHENE	40	40	8.1	-
FLUORENE	5.1	5.1	3.9	-
HEPTACHLOR	0.013	0.013	0.0036	0.00021
HEPTACHLOR EPOXIDE	0.014	0.014	0.0036	0.00011
HEXACHLOROBENZENE	0.27	1.4	3.7	0.00077
HEXACHLOROBUTADIENE	2.4	32	9.3	-
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	0.049	0.049	0.08	0.063
HEXACHLOROETHANE	12	41	12	8.9
INDENO(1,2,3-cd)PYRENE	0.38	1.8	0.27	0.049
LEAD	200	750	3.2	-
MERCURY	4.7	10	0.012	0.051
METHOXYCHLOR	19	19	0.03	-
METHYLENE CHLORIDE	0.89 (4.2)	3.1 (9.6)	2200	1600

TABLE B. SURFACE SOIL (≤ 3m bgs) SOIL AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
METHYL ETHYL KETONE	13	13	14000	-
METHYL ISOBUTYL KETONE	3.8	3.8	170	-
METHYL MERCURY	1.2	10	0.003	-
METHYLNAPHTHALENE (total 1- & 2-)	0.25	0.25	2.1	-
METHYL TERT BUTYL ETHER	1.0	1.0	1800	
MOLYBDENUM	40	40	240	-
NAPHTHALENE	1.7 (4.9)	4.9	24	-
NICKEL	150	150	8.2	-
PENTACHLOROPHENOL	4.4	5.0	7.9	-
PERCHLORATE	1.2	1.2	600	-
PHENANTHRENE	11	11	4.6	-
PHENOL	39	39	2560	-
POLYCHLORINATED BIPHENYLS (PCBs)	0.22	1.0	0.014	0.00017
PYRENE	55	55	0.40	-
SELENIUM	10	10	5.0	-
SILVER	20	40	0.12	-
STYRENE	17	17	100	-
TETRACHLOROETHANE, 1,1,1,2-	3.0	7.0	930	-
TETRACHLOROETHANE, 1,1,2,2-	0.024 (0.37)	0.093 (0.88)	420	11
TETRACHLOROETHYLENE	0.15 (0.95)	0.53 (2.1)	120	8.85
THALLIUM	1.0	29	40	6.3
TOLUENE	8.4	8.4	130	-
TPH (gasolines)	400	400	500	
TPH (middle distillates)	500	500	640	-
TPH (residual fuels)	500	1000	640	-
TRICHLOROBENZENE, 1,2,4-	15	15	50	-
TRICHLOROETHANE, 1,1,1-	8.0	8.0	62	-
TRICHLOROETHANE, 1,1,2-	0.055 (0.81)	0.19 (1.8)	930 (8200)	42
TRICHLOROETHYLENE	0.44 (1.7)	1.5 (3.7)	360	81
TRICHLOROPHENOL, 2,4,5-	0.18	0.18	11	-
TRICHLOROPHENOL, 2,4,6-	6.9	10	970	6.5
VANADIUM	110	200	19	-
VINYL CHLORIDE	0.011	0.040	4.9 (120)	525
XYLENES	1.0	1.0	13	-
ZINC	600	600	23	-

TABLE B. SURFACE SOIL (≤ 3m bgs) SOIL AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs) (Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	no criteria	no criteria
Sodium Adsorption Ratio	5.0	12	no criteria	no criteria

Notes:

Source of soil RBSLs: Refer to Tables B-1 and B-2 in Appendix 1.

Source of groundwater RBSLs: Refer to Table F-2 Appendix 1.

Category "Residential Land Use Permitted" based on residential land-use scenario and generally considered adequate for unrestricted land use.

Surface soil less than or equal to 3 meters (approximately 10 feet) below ground surface.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 1.2).

Soil RBSLs intended to address direct-exposure, indoor-air impact, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. Refer to appendices for summary of RBSL components.

Groundwater RBSLs intended to be protective of surface water quality, indoor-air impacts and nuisance concerns.

Value in parentheses applicable if vadose zone soils are predominantly fine-grained, silty, clayey loams (<20% sand-size (0.075mm) or larger material; i.e. ≥80% of soil material will pass through 200 mesh sieve).

Category "Elevated Threat To Surface Water" screening levels address potential long-term impacts to surface water bodies and bioaccumulation concerns in aquatic organisms potentially consumed by humans. Not addressed in soil RBSLs.

TPH -Total Petroleum Hydrocarbons. See Appendix 1, Chapter 4 for discussion of different TPH categories.

TABLE C: SUBSURFACE SOIL (>3M BGS) - GROUNDWATER IS A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential RBSLs and evaluate need for formal land-use restrictions (see Section 2.9).
- Use of groundwater RBSLs for sites with fine-grained soils (in parentheses) requires presence of continuous, low permeability clay/silt unit between impacted groundwater and the ground surface $\geq$1.5 meters thick (see Section 1.5).
- Subsurface RBSLs may be applicable to shallower soils at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.4 and Section 2.9).

TABLE C. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
ACENAPHTHENE	16	16	20	-
ACENAPHTHYLENE	120	120	280	-
ACETONE	0.24	0.24	700	-
ALDRIN	0.95	0.95	0.002	0.00014
ANTHRACENE	2.9	2.9	0.73	-
ANTIMONY	210	210	6.0	-
ARSENIC	13	13	36	-
BARIUM	2400	2400	3.9	-
BENZENE	0.045	0.045	1.0	-
BENZO(a)ANTHRACENE	12	12	0.029	-
BENZO(b)FLUORANTHENE	12	12	0.029	-
BENZO(k)FLUORANTHENE	2.7	2.7	0.029	0.049
BENZO(g,h,i)PERYLENE	5.3	5.3	0.02	-
BENZO(a)PYRENE	1.2	1.2	0.014	-
BERYLLIUM	95	95	4.0	-
BIPHENYL, 1,1-	0.65	0.65	0.50	-
BIS(2-CHLOROETHYL)ETHER	0.0002	0.0002	0.014	-
BIS(2-CHLOROISOPROPYL)ETHER	0.005	0.005	0.50	-
BIS(2-ETHYLHEXYL)PHTHALATE	200	200	12	-
BORON	23000	23000	1.6	-
BROMODICHLOROMETHANE	0.025 (0.95)	0.098 (2.7)	100	-
BROMOFORM	2.2	2.2	100	-
BROMOMETHANE	0.39	0.39	9.8	-
CADMIUM	33	33	1.1	-
CARBON TETRACHLORIDE	0.021 (0.059)	0.074 (0.11)	0.50	-
CHLORDANE	15	15	0.004	0.00059
CHLOROANILINE, p-	0.11	0.11	10	-
CHLOROBENZENE	3.0	3.0	50	-
CHLOROETHANE	0.85	0.85	12	-
CHLOROFORM	0.17 (0.88)	0.58 (0.88)	28	-
CHLOROMETHANE	0.42	0.42	2.7	-
CHLOROPHENOL, 2-	0.012	0.012	0.18	-
CHROMIUM (Total - assumes 1/6 ratio Cr6/Cr3)	13	13	50	-
CHROMIUM III	2500	5000	180	-
CHROMIUM VI	1.8	1.8	11	-
CHRYSENE	19	19	0.29	0.049
COBALT	2500	5000	3.0	-
COPPER	2500	5000	3.1	-
CYANIDE (Free)	500	1000	1.0	-
DIBENZO(a,h)ANTHTRACENE	3.5	3.5	0.0085	0.049
DIBROMOCHLOROMETHANE	8.3	8.3	100	46

TABLE C. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
1,2-DIBROMO-3-CHLOROPROPANE	0.001	0.001	0.20	-
DIBROMOETHANE, 1,2-	0.0003	0.0003	0.05	-
DICHLOROBENZENE, 1,2-	0.75	0.75	10	-
DICHLOROBENZENE, 1,3-	0.47	0.47	6.3	-
DICHLOROBENZENE, 1,4-	0.13 (0.59)	0.49 (0.59)	5.0	-
DICHLOROBENZIDINE, 3,3-	0.008	0.008	0.029	0.077
DICHLORODIPHENYLDICHLOROETHANE (DDD)	91	91	0.06	0.00084
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	64	64	0.10	0.00059
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3	4.3	0.001	0.00059
DICHLOROETHANE, 1,1-	0.22	0.22	5.0	-
DICHLOROETHANE, 1,2-	0.006	0.006	0.50	-
DICHLOROETHYLENE, 1,1-	0.018 (0.028)	0.062 (0.12)	6.0	3.2
DICHLOROETHYLENE, Cis 1,2-	0.19	0.19	6.0	-
DICHLOROETHYLENE, Trans 1,2-	0.65	0.65	10	-
DICHLOROPHENOL, 2,4-	0.30	0.30	0.30	-
DICHLOROPROPANE, 1,2-	0.049 (0.13)	0.13	5.0	-
DICHLOROPROPENE, 1,3-	0.055 (0.057)	0.057	0.50	-
DIELDRIN	0.002	0.002	0.0019	0.00014
DIETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHENOL, 2,4-	0.68	0.68	100	-
DINITROPHENOL, 2,4-	0.040	0.040	14	-
DINITROTOLUENE, 2,4-	0.0008	0.0008	0.11	-
1,4 DIOXANE	0.0018	0.0018	3.0	-
DIOXIN (2,3,7,8-TCDD)	0.00017	0.00017	<0.00001	0.000000014
ENDOSULFAN	0.005	0.005	0.0087	-
ENDRIN	0.0006	0.0006	0.0023	-
ETHYLBENZENE	2.5	2.5	30	-
FLUORANTHENE	60	60	8.1	-
FLUORENE	5.1	5.1	3.9	-
HEPTACHLOR	0.013	0.013	0.0036	0.00021
HEPTACHLOR EPOXIDE	0.014	0.014	0.0036	0.00011
HEXACHLOROBENZENE	9.0	9.0	1.0	0.00077
HEXACHLOROBUTADIENE	2.2	2.2	0.45	-
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	0.049	0.049	0.08	0.063
HEXACHLOROETHANE	3.0	3.0	0.90	8.9
INDENO(1,2,3-cd)PYRENE	7.7	7.7	0.029	0.049
LEAD	750	750	3.2	-
MERCURY	160	160	0.012	-
METHOXYCHLOR	19	19	0.03	-

TABLE C. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
METHYLENE CHLORIDE	0.076	0.076	5.0	-
METHYL ETHYL KETONE	3.8	3.8	4200	-
METHYL ISOBUTYL KETONE	2.7	2.7	120	-
METHYL MERCURY	33	33	0.003	-
METHYLNAPHTHALENE (total 1- & 2-)	0.25	0.25	2.1	-
METHYL TERT BUTYL ETHER	0.028	0.028	5.0	
MOLYBDENUM	2500	2700	35	-
NAPHTHALENE	1.7 (4.3)	4.3	21	-
NICKEL	1000	1000	8.2	-
PENTACHLOROPHENOL	5.3	5.3	1.0	-
PERCHLORATE	0.036	0.036	18	
PHENANTHRENE	11	11	4.6	-
PHENOL	0.076	0.076	5.0	-
POLYCHLORINATED BIPHENYLS (PCBs)	5.6	5.6	0.014	0.00017
PYRENE	55	55	0.40	-
SELENIUM	2500	2700	5.0	-
SILVER	2500	2700	0.12	-
STYRENE	1.7	1.7	10	-
TETRACHLOROETHANE, 1,1,1,2-	0.020	0.020	1.3	-
TETRACHLOROETHANE, 1,1,2,2-	0.015	0.015	1.0	-
TETRACHLOROETHYLENE	0.15 (0.80)	0.53 (0.80)	5.0	-
THALLIUM	35	35	2.0	-
TOLUENE	2.6	2.6	40	-
TPH (gasolines)	100	100	100	
TPH (middle distillates)	100	100	100	-
TPH (residual fuels)	1000	1000	100	-
TRICHLOROBENZENE, 1,2,4-	15	15	50	-
TRICHLOROETHANE, 1,1,1-	8.0	8.0	62	-
TRICHLOROETHANE, 1,1,2-	0.055 (0.091)	0.091	5.0	-
TRICHLOROETHYLENE	0.40	0.40	5.0	-
TRICHLOROPHENOL, 2,4,5-	0.18	0.18	11	-
TRICHLOROPHENOL, 2,4,6-	0.17	0.17	0.50	-
VANADIUM	2500	3700	19	-
VINYL CHLORIDE	0.011 (0.011)	0.040 (0.040)	0.50	-
XYLENES	1.0	1.0	13	-
ZINC	2500	5000	23	-

TABLE C. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	**Residential Land Use Permitted (mg/kg)**	**Commercial/ Industrial Land Use Only (mg/kg)**	**Drinking Water Resource Threatened (ug/L)**	**Elevated Threat To Surface Water (ug/L)**
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	no criteria	no criteria
Sodium Adsorption Ratio	not applcable	not applicable	no criteria	no criteria

Notes:

Source of soil RBSLs: Refer to Tables C-1 and C-2 in Appendix 1.

Source of groundwater RBSLs: Refer to Table F-1 Appendix 1.

Category "Residential Land Use Permitted" based on residential land-use scenario and generally considered adequate for unrestricted land use.

Subsurface soil greater than 3 meters (approximately 10 feet) below ground surface.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 1.2).

Soil RBSLs intended to address human health, groundwater protection, indoor air and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios for indoor air impacts. Refer to appendices for summary of RBSL components.

Groundwater RBSLs intended to be protective of drinking water resources, surface water quality, indoor-air impacts and nuisance concerns.

Value in parentheses applicable if vadose zone soils are predominantly fine-grained, silty, clayey loams (<20% sand-size (0.075mm) or larger material; i.e. ≥80% of soil material will pass through 200 mesh sieve).

Category "Elevated Threat To Surface Water" screening levels address potential long-term impacts to surface water bodies and bioaccumulation concerns in aquatic organisms potentially consumed by humans. Not addressed in soil RBSLs.

TPH -Total Petroleum Hydrocarbons. See Appendix 1, Chapter 4 for discussion of different TPH categories.

TABLE D: SUBSURFACE SOIL (>3M BGS) - GROUNDWATER IS NOT A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential RBSLs and evaluate need for formal land-use restrictions (see Section 2.9).
- Use of groundwater RBSLs for sites with fine-grained soils (in parentheses) requires presence of continuous, low permeability clay/silt unit between impacted groundwater and the ground surface $\geq$1.5 meters thick (see Section 1.5).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.3).
- Subsurface RBSLs may be applicable to shallower soils at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.4 and Section 2.9).

TABLE D. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
ACENAPHTHENE	16	16	23	-
ACENAPHTHYLENE	120	120	280	-
ACETONE	0.51	0.51	1500	-
ALDRIN	0.95	0.95	0.13	0.00014
ANTHRACENE	2.9	2.9	0.73	-
ANTIMONY	210	210	30	-
ARSENIC	13	13	36	-
BARIUM	2400	2400	3.9	-
BENZENE	0.18	0.39	46	-
BENZO(a)ANTHRACENE	12	12	0.027	0.049
BENZO(b)FLUORANTHENE	12	12	7.0	0.049
BENZO(k)FLUORANTHENE	12	12	0.40	0.049
BENZO(g,h,i)PERYLENE	5.3	5.3	0.02	-
BENZO(a)PYRENE	1.2	1.2	0.014	-
BERYLLIUM	95	95	5.1	-
BIPHENYL, 1,1-	6.5	6.5	5.0	-
BIS(2-CHLOROETHYL)ETHER	0.015 (1.6)	0.061 (1.6)	122	1.4
BIS(2-CHLOROISOPROPYL)ETHER	1.3	1.3	122	-
BIS(2-ETHYLHEXYL)PHTHALATE	530	530	32	5.9
BORON	23000	23000	1.6	-
BROMODICHLOROMETHANE	0.025 (0.95)	0.098 (4.0)	420 (6400)	-
BROMOFORM	110	110	5100	360
BROMOMETHANE	13	1.1 (3.0)	320	-
CADMIUM	33	33	1.1	-
CARBON TETRACHLORIDE	0.021 (0.059)	0.074 (0.25)	9.8	4.4
CHLORDANE	15	15	0.004	0.00059
CHLOROANILINE, p-	0.11	0.11	10	-
CHLOROBENZENE	3.0	3.0	50	-
CHLOROETHANE	0.85	0.85	12	-
CHLOROFORM	0.17 (0.88)	0.58 (0.88)	28	470
CHLOROMETHANE	0.49	0.87 (1.7)	5.6 (130)	-
CHLOROPHENOL, 2-	0.12	0.12	1.8	400
CHROMIUM (Total - assumes 1/6 ratio Cr6/Cr3)	13	13	180	-
CHROMIUM III	2500	5000	180	-
CHROMIUM VI	18	1.8	11	-
CHRYSENE	4.7	4.7	0.07	0.049
COBALT	2500	5000	3.0	-
COPPER	2500	5000	3.1	-
CYANIDE (Free)	500	1000	1.0	-
DIBENZO(a,h)ANTHTRACENE	3.5	3.5	0.25	0.049
DIBROMOCHLOROMETHANE	79	79	6400	-

TABLE D. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
1,2-DIBROMO-3-CHLOROPROPANE	0.001	0.001	0.20	-
DIBROMOETHANE, 1,2-	0.014 (0.56)	0.052 (0.56)	84 (280)	-
DICHLOROBENZENE, 1,2-	1.0	1.0	14	-
DICHLOROBENZENE, 1,3-	5.3	5.3	71	-
DICHLOROBENZENE, 1,4-	0.13 (1.8)	0.49 (1.8)	15	-
DICHLOROBENZIDINE, 3,3-	13	13	50	0.077
DICHLORODIPHENYLDICHLOROETHANE (DDD)	91	91	0.06	0.00084
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	64	64	1.4	0.00059
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3	4.3	0.001	0.00059
DICHLOROETHANE, 1,1-	0.55 (2.1)	1.9 (2.1)	47	-
DICHLOROETHANE, 1,2-	0.040 (0.85)	0.14 (3.6)	500 (910)	99
DICHLOROETHYLENE, 1,1-	0.018 (0.028)	0.062 (0.12)	9.6 (25)	3.2
DICHLOROETHYLENE, Cis 1,2-	2.7 (16)	7.7 (18)	590	-
DICHLOROETHYLENE, Trans 1,2-	5.3 (16)	15 (38)	590	-
DICHLOROPHENOL, 2,4-	3.0	3.0	3.0	-
DICHLOROPROPANE, 1,2-	0.049 (0.50)	0.17 (2.1)	100	39
DICHLOROPROPENE, 1,3-	0.055 (0.090)	0.19 (0.38)	65 (244)	-
DIELDRIN	0.002	0.002	0.0019	0.00014
DIETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHTHALATE	0.070	0.070	3.0	-
DIMETHYLPHENOL, 2,4-	0.74	0.74	110	-
DINITROPHENOL, 2,4-	0.42	0.42	150	-
DINITROTOLUENE, 2,4-	1.7	1.7	230	9.1
1,4 DIOXANE	0.20	0.20	335	-
DIOXIN (2,3,7,8-TCDD)	0.00017	0.00017	<0.00001	0.000000014
ENDOSULFAN	0.005	0.005	0.0087	-
ENDRIN	0.0006	0.0006	0.0023	-
ETHYLBENZENE	24	24	290	-
FLUORANTHENE	60	60	8.1	-
FLUORENE	5.1	5.1	3.9	-
HEPTACHLOR	0.013	0.013	0.0036	0.00021
HEPTACHLOR EPOXIDE	0.014	0.014	0.0036	0.00011
HEXACHLOROBENZENE	9.0	9.0	3.7	0.00077
HEXACHLOROBUTADIENE	46	46	9.3	-
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	0.049	0.049	0.08	0.063
HEXACHLOROETHANE	41	41	12	8.9
INDENO(1,2,3-cd)PYRENE	12	72	0.27	0.049
LEAD	750	750	3.2	-
MERCURY	160	160	0.012	0.051
METHOXYCHLOR	19	19	0.03	-
METHYLENE CHLORIDE	0.89 (4.2)	3.1 (18)	2200	1600

TABLE D. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs)
(Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
METHYL ETHYL KETONE	13	13	14000	-
METHYL ISOBUTYL KETONE	3.8	3.8	170	-
METHYL MERCURY	33	33	0.003	-
METHYLNAPHTHALENE (total 1- & 2-)	0.25	0.25	2.1	-
METHYL TERT BUTYL ETHER	1.0	1.0	1800	
MOLYBDENUM	2500	2700	240	-
NAPHTHALENE	1.7 (4.9)	4.9	24	-
NICKEL	1000	1000	8.2	-
PENTACHLOROPHENOL	42	42	7.9	-
PERCHLORATE	1.2	1.2	600	
PHENANTHRENE	11	11	4.6	-
PHENOL	39	39	2560	-
POLYCHLORINATED BIPHENYLS (PCBs)	5.6	5.6	0.014	0.00017
PYRENE	55	55	0.40	-
SELENIUM	2500	2700	5.0	-
SILVER	2500	2700	0.12	-
STYRENE	17	17	100	-
TETRACHLOROETHANE, 1,1,1,2-	14	14	930	-
TETRACHLOROETHANE, 1,1,2,2-	0.024 (2.0)	0.093 (6.4)	420	11
TETRACHLOROETHYLENE	0.15 (1.1)	0.53 (4.8)	120	8.85
THALLIUM	37	35	40	6.3
TOLUENE	8.4	8.4	130	-
TPH (gasolines)	400	400	500	
TPH (middle distillates)	500	500	640	-
TPH (residual fuels)	1000	1000	640	-
TRICHLOROBENZENE, 1,2,4-	15	15	50	-
TRICHLOROETHANE, 1,1,1-	8.0	8.0	62	-
TRICHLOROETHANE, 1,1,2-	0.055 (2.5)	0.19 (10)	930 (8200)	42
TRICHLOROETHYLENE	0.44 (2.2)	1.5 (9.3)	360	81
TRICHLOROPHENOL, 2,4,5-	0.18	0.18	11	-
TRICHLOROPHENOL, 2,4,6-	230	230	970	6.5
VANADIUM	2500	3700	19	-
VINYL CHLORIDE	0.011 (0.011)	0.040 (0.040)	4.9 (120)	525
XYLENES	1.0	1.0	13	-
ZINC	2500	5000	23	-

TABLE D. SUBSURFACE SOIL (> 3m bgs) AND GROUNDWATER RISK-BASED SCREENING LEVELS (RBSLs) (Groundwater IS NOT a Current or Potential Source of Drinking Water)

	SUBSURFACE SOIL RBSLs		GROUNDWATER RBSLs	
CHEMICAL PARAMETER	Residential Land Use Permitted (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	Drinking Water Resource NOT Threatened (ug/L)	Elevated Threat To Surface Water (ug/L)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	no criteria	no criteria
Sodium Adsorption Ratio	not applicable	not applicable	no criteria	no criteria

Notes:

Source of soil RBSLs: Refer to Tables D-1 and D-2 in Appendix 1.

Source of groundwater RBSLs: Refer to Table F-2 Appendix 1.

Category "Residential Land Use Permitted" based on residential land-use scenario and generally considered adequate for unrestricted land use.

Subsurface soil greater than 3 meters (approximately 10 feet) below ground surface.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 1.2).

Soil RBSLs intended to address human health, groundwater protection, indoor air and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios for indoor air impacts. Refer to appendices for summary of RBSL components.

Groundwater RBSLs intended to be protective of surface water quality, indoor-air impacts and nuisance concerns.

Value in parentheses applicable if vadose zone soils are predominantly fine-grained, silty, clayey loams (<20% sand-size (0.075mm) or larger material; i.e. ≥80% of soil material will pass through 200 mesh sieve).

Category "Elevated Threat To Surface Water" screening levels address potential long-term impacts to surface water bodies and bioaccumulation concerns in aquatic organisms potentially consumed by humans. Not addressed in soil RBSLs.

TPH -Total Petroleum Hydrocarbons. See Appendix 1, Chapter 4 for discussion of different TPH categories.